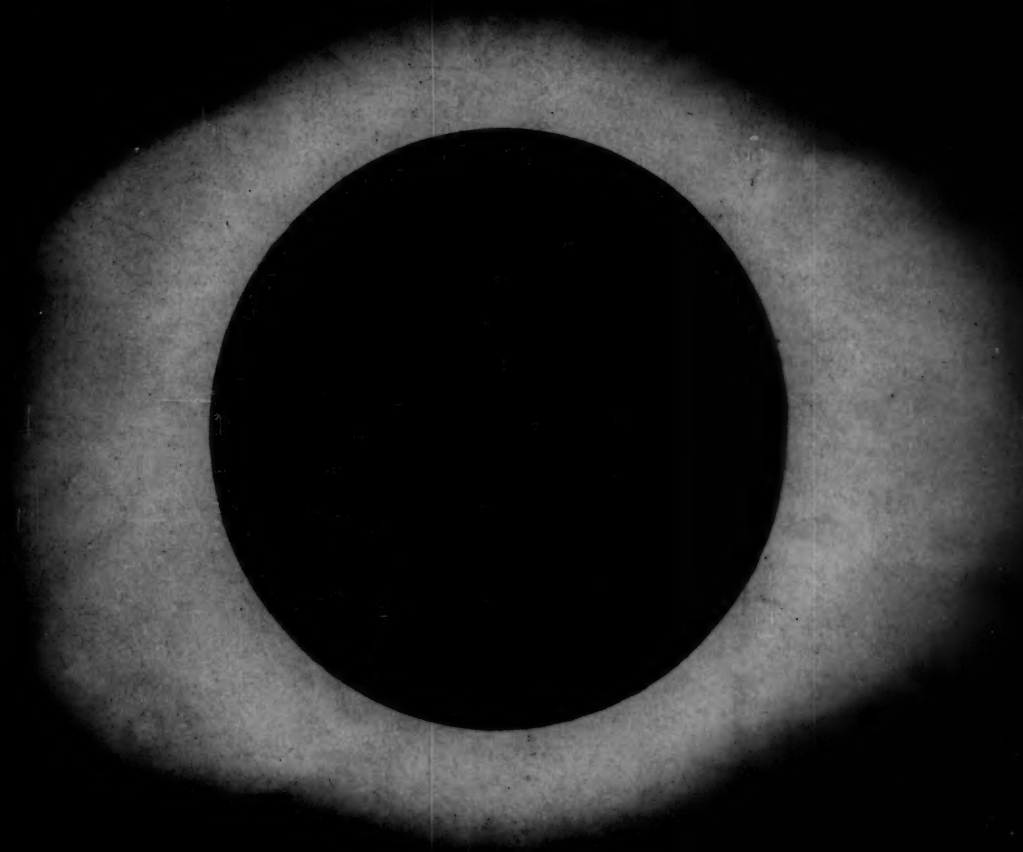


MAY 3 1944

*and*

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# Sky and TELESCOPE

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## The Editors Note . . .

READERS of this periodical are mostly not college students, but what Dr. Victor Goedicke, of Yale University Observatory, has to say regarding astronomy textbooks in general concerns amateur astronomers and would-be amateurs, as well as "those liberal arts students who intend to take no further courses in astronomy" and for whom Dr. Goedicke proposes a new kind of textbook.

The Yale astronomer presents a tentative outline for part of his text in the March issue of **Popular Astronomy**. He expresses his respect for existing astronomy textbooks, but states that most of them have been written to serve simultaneously the student as a text and the astronomer as a reference—in most cases the astronomers have received the lion's share of the attention.

Daily we receive requests for recommended reading from students of all stages of astronomical interest and training, also from amateurs planning study groups; often these express disappointment with available works, and perhaps Dr. Goedicke's proposal will solve their prob-

lem. Our quotations from his article require little comment:

"In my classes, the students have invariably found the sections on the physical properties and the motions of the stars most difficult. The difficulty appears to arise from a feeling that these sections of the book consist of a large collection of unrelated facts, with no clearly apparent unifying pattern. Insofar as this feeling is justified, it constitutes an overwhelming barrier to the student's progress . . . if the facts in any course cannot be fitted into a logical pattern the game is lost.

"It is not good practice to introduce independent descriptive material whose primary significance will appear later; it is much better to postpone the topic until it can be introduced as part of the solution to a larger problem which is already before the student." He suggests discussing the problem of stellar temperatures as a whole, introducing the spectral sequence as one aspect of the question; use of the spectral sequence for other purposes is not sufficient reason for mak-

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BACK COVER: Brooks' comet, photographed by E. E. Barnard at Yerkes Observatory, October 23, 1911, four days before the comet reached perihelion. This celestial visitor was visible to the naked eye for four months. (See page 12.)

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# THE NATURE OF COSMIC RAYS

By W. F. G. SWANN

Director, Bartol Research Foundation of The Franklin Institute

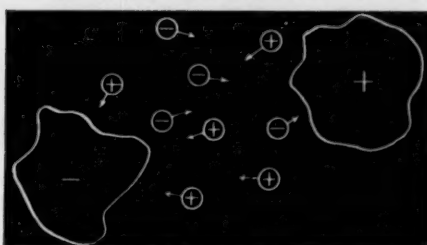
## PART I\*

IF OUR eyes could be made to magnify what they now see 10 million million times, the space which is around us would look something like a turbulent thunderstorm with the rain and hail pouring down from all directions. In this deluge around us would be found, in varying degree, free from the encumbrance of matter in bulk, about all the atomic particles which the physics of the last five decades has forced out of that seclusion where nature has held them secret from the prying eyes of those as close to us in time as our grandfathers. An atomic umbrella would be worse than useless in shielding you from this atomic thunderstorm; for even an armor of lead would only enhance your troubles by irritating the particles of this cosmic rain to the point of propagating their species in the armor and deluging you more than if you had not sought to protect yourself. Traveling with speeds a million times greater than that of a bullet from the highest power rifle known, these particles are now shooting right through your bodies at the rate of about 10 per second for each one of you. Each of them is tearing apart about a million of your personal molecules as it passes through you, so that you each have some 10 million molecules damaged per second. Do not be alarmed, however, you are not wearing away very fast. A speck of dust which is almost invisible contains a million times as many molecules as there are people on the face of the earth. You can afford to lose a few million. These mysterious raindrops, this artillery fire, which space spreads as a continual barrage around you, constitutes in its totality what we call the *cosmic radiation*. But before proceeding further, let us inquire how this mysterious radiation first came to our attention.

### 1. Discovery of the cosmic radiation

THOSE phenomena we now attribute to the cosmic radiation came first to our attention by virtue of the fact that the atmosphere possesses in very slight degree the power to conduct

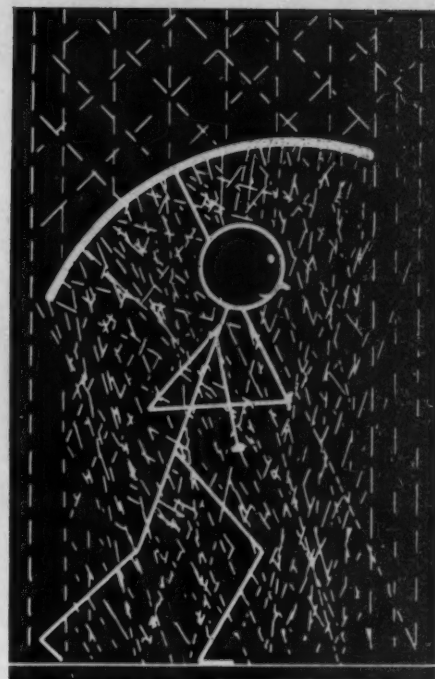
electricity. We know that this power exists by the presence in the air of what may be called broken atoms or molecules—atoms or molecules from which a particle of negative electricity has been detached, leaving them positively charged. The negative particles attach themselves to other atoms or molecules, so that we have in the atmosphere positively and negatively charged entities which can move about under the influences of electric forces and serve, in consequence, as the vehicles of conveyance of electricity from one place to another. Atoms and molecules, when broken in the foregoing manner, heal very quickly if left to themselves. Those which have gained a negative charge seek out those which have lost one and generously return it, so that if the power to conduct electricity is to be maintained, there must be present, continually, some agency responsible for breaking up more atoms. The situation is something like that of a dance in which the neutral atoms are represented by dancing partners. Suppose that, while the dance is progressing, a number



The large positively and negatively charged bodies become discharged by the charged ions in the air.

of demons fly through the ballroom, tearing the couples apart, and suppose that each partner so separated seeks another as quickly as possible, then we have a kind of picture of what is happening in the atmosphere. The greater the number of demons, the greater the number of partners which are, at any moment, free.

Now the important thing which was discovered by Prof. Victor F. Hess, about 1911, was that the rate of destruction of atoms of gas in a closed vessel increased very considerably with altitude above the surface of the earth, indicating that the bombardment increases as we ascend. This result is to be expected if the bombarding bullets come from outside of our atmosphere and are absorbed to greater and greater extent as they



The cosmic ray umbrella affords him no protection. He would be better off without it.

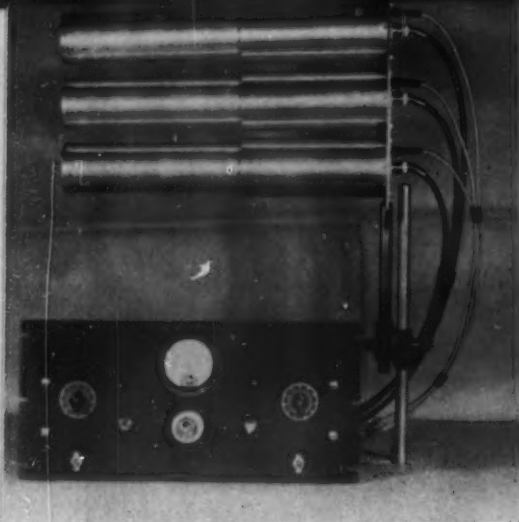
penetrate, as bullets shot into a forest would be absorbed by the trees. By finding how the intensity of bombardment diminished with descent into the atmosphere from above, it was possible to come to some conclusion as to the penetrating power of these rays—these cosmic bullets. At the time of their discovery, they were deemed to have a penetrating power 10 times as great as that of any other kind of ray which we had previously met in the laboratory. We now know that their penetrating power is even greater than was then supposed, and that a measurable number of these rays can pass through as much as 75 feet of lead.

Since the work of Hess was done, many have followed in the field. R. A. Millikan and his collaborators have made careful measurements over lakes, on mountains, and during sea voyages. J. C. Clay, in Holland, was responsible for demonstrating a remarkable variation of cosmic ray intensity with latitude, and the effect was pursued by A. H. Compton and his collaborators in a world-wide survey. T. H. Johnson and J. C. Street observed an asymmetry of the radiation as regards the east and west directions, an effect which was soon confirmed by further experiments of Johnson, and by Compton and L. W. Alvarez working simultaneously. These effects, taken in conjunction with the latitude variation, have played a profound part in establishing the nature of the cosmic rays.

The Bartol Foundation placed apparatus on the two balloons which were sent high into the stratosphere by the National Geographic Society in collaboration with the U. S. Army Air Corps,

\*This article, which will appear in several installments, is based upon material prepared by the author for the Director's Report and published in the *Journal of The Franklin Institute*.





Apparatus designed by the Bartol Research Foundation to cause a cosmic ray to turn on the World's Fair lights in 1939. The three metal tubes enclose three Geiger counters arranged as in the apparatus pictured below. The wider parts of the tubes contain the first stages of the amplifying circuit; the remainder is behind the panel.

and it also supplied the cosmic ray apparatus for the flight made by Prof. and Mrs. Jean Piccard. In one of these flights, which reached 72,000 feet, our apparatus showed that the radiation continued to increase with altitude, until at about 57,000 feet it started to diminish with greater altitude. This result was observed also, and at about the same time, by E. Regener who, working in Germany, sent small pilot balloons with self-recording apparatus high into the stratosphere. Millikan and his collaborators have used similar self-recording apparatus in observations made in various parts of the world, and Johnson, and also S. A. Korff, have done important work with such balloons, using the radio technique for receiving records from the balloons, a method first developed in its important essentials by the meteorologists. Korff and E. T. Clarke have also been responsible for measurements made in the vicinity of the South Pole.

The radiation has been pursued into deep mines. All sorts of ingenious devices have been invented for examining it, including cloud chambers which render the paths of the rays visible, and such devices have been used for ferreting out what happens to the cosmic radiation when it passes through matter. Some of the rays live for only a short time—about a millionth of a second—and this time has been measured.

As a result of such researches as those cited, a great deal of information concerning this radiation has been accumulated, and it is to such information that we must look in order to find an answer to the question, "What are the cosmic rays?"

Before speaking of the characteristics of this radiation, however, and of the facts which brought it to our notice, let

me first introduce you a little more intimately to the particles of atomic physics which I have mentioned; for, as I have already implied, it is to them that we look for an explanation of those startling phenomena which a study of what we call the cosmic radiation has revealed. Physicists are snooty people; it takes a very great deal of effort on the part of anything which is a candidate for the job of being a fundamental brick in nature's structure to gain an entrance to the community of things already known. When research reveals, as it has in the phenomena of the cosmic radiation, new phenomena which seem to call for an explanation in terms of some kinds of atomic particles, we prefer to seek among those already at our disposal and let them take on the duties of the new requirements, rather than appoint from our imagination new things to take over these duties. The particles which our studies of atomic physics had already placed before us filled a useful purpose in the beginnings of our understanding of these mysterious rays. And then the rays paid their debt by becoming instrumental in the actual discovery of new particles which not only served the requirements of the rays themselves, but illuminated still further our understanding of certain atomic processes which, incomplete as they were in our theories, had generously given their aid to understanding when the science of cosmic rays was born.

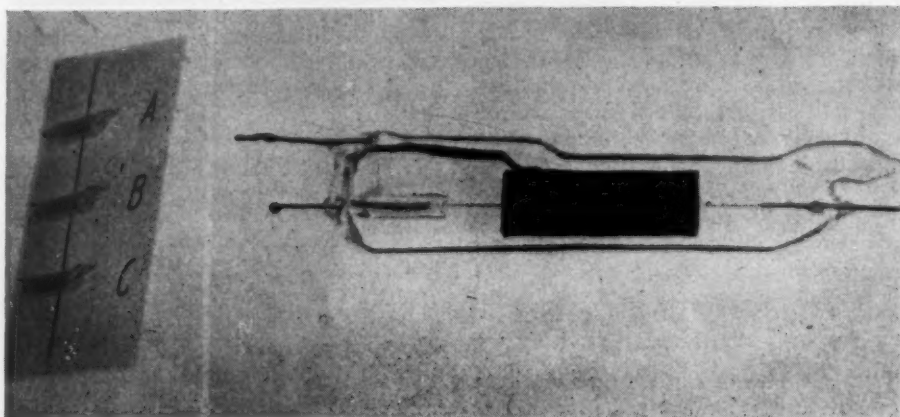
## 2. The standardized parts of nature's structure: the atomic particles of physics

THESE are days of standardized parts.

In the olden times the craftsman who started the construction of some machine, ship, or building, would choose or make his screws, nails, bricks, with relation only to the job in hand and

without any particular consideration of the sizes and types of these things used in the structures made by others. As the complexity of our civilization has increased, however, and as the output of appliances used by mankind has grown; as orders have been placed for several ships instead of one; as people have demanded the delivery of hundreds of automobiles at a time, our engineers have come to standardize the fundamental things out of which the appliances we use are made. Instead of making a special set of screws for every job, we try to design a set of screw sizes which will be applicable to all jobs. The fewer the totality of sizes necessary for the purpose, the happier we are. The skyscraper looks very different from the battleship, but when I go far enough down to the details of construction I recognize screws of the same size, bolts of the same size, and possibly paint of the same kind in the battleship as I find in the skyscraper.

Now the modern engineer is very proud of his system of standardization of parts. It is quite true that he has a far less number of fundamental parts than he would have been encumbered with had he given no attention to standardization; but nevertheless he has a very great number of such parts. Still he is very proud of what he has done, forgetful, perhaps, of the fact that he was not the first in the field of the standardization of parts; for before him was the oldest builder and architect of all time, the grand architect of the universe. In this great structure of the universe, varying in pictorial significance from the great nebulae of space, the stars of the heavens, the planets of our solar system, to the rocks and waters of the earth, the foliage of the woods and forests, we find a condition in which the closer we peer into the structure, the



A Geiger-Mueller counter. A tungsten wire runs coaxially through a metal cylinder enclosed in a glass tube filled with a suitable gas at reduced pressure. When a suitable potential difference is maintained between wire and cylinder, the cosmic ray passing through the cylinder precipitates an electrical discharge which can operate a recording mechanism. At left, A, B, and C represent three counters in tandem. The recording mechanism is designed so as to operate only when all three counters discharge simultaneously, that is, when a single ray passes through all three. Such an arrangement can be used as a Geiger counter telescope.



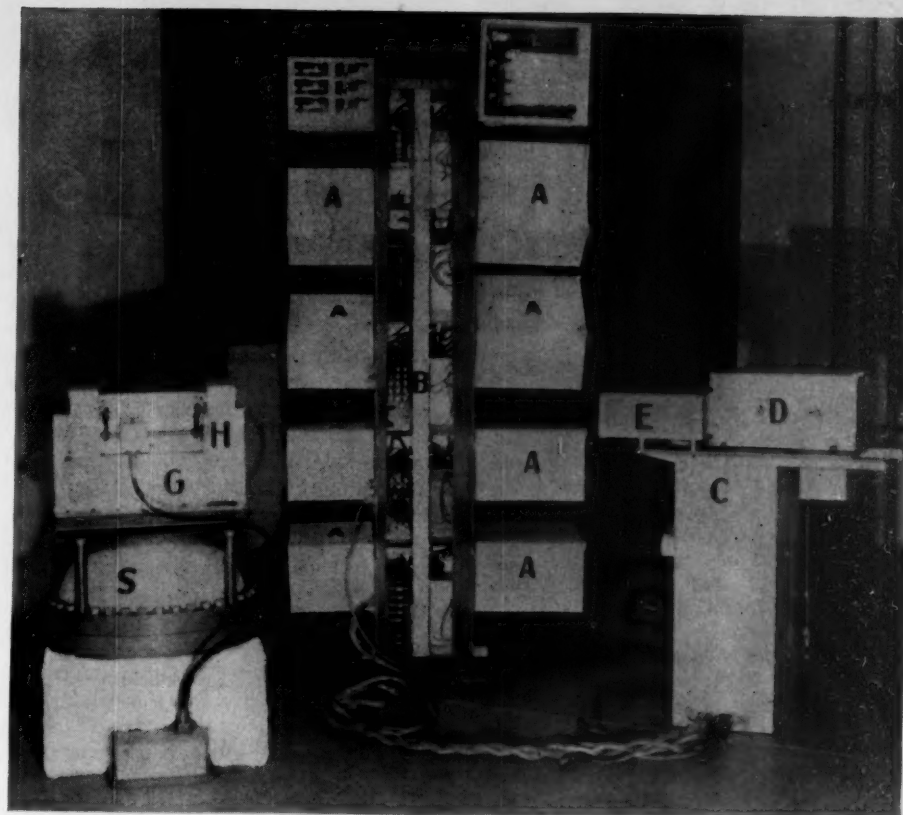
more we get down to things which are alike for all.

Nearly everybody knows that all matter is made up of 92 individual kinds of what we may call primitive matter or *elements*. Hydrogen is an element, oxygen is an element, copper is an element, as are lead, magnesium, helium, and so on. The most obvious characteristic of the elements is that by ordinary means we cannot change them into anything else. We can break up water into hydrogen and oxygen by use of the electric current, but by no means at our disposal, at any rate until recent times, was it possible to change oxygen or hydrogen into anything else. Oxygen and hydrogen are elements; water is a compound, made up of these two elements.

Until 50 years ago it was believed that in getting down to these 92 elements we had reached the ultimate standardized parts out of which the universe is built. Then toward the end of the last century a new kind of particle, of extremely small mass and carrying a negative electric charge, was discovered. A remarkable thing about this particle was the fact that it appeared capable of being obtained from all substances, from copper, from zinc, from iron, from everything. It seemed, in fact, very clear that this particle, now called the *negative electron*, was one of the fundamental standardized parts of nature's structure, and from that time onward, there became ingrained in our minds with ever-increasing conviction the idea that these standardized parts which we call atoms must themselves be made up from a much fewer number of other standardized parts.

Soon after the discovery of this particle, another of these fundamental bricks, the *proton*, made its appearance. It is a positively charged particle with a mass 2,000 times that of the electron; and in terms of the school of thought of the day, a thing so small that if everything in the universe were magnified until the proton attained the size of a pin's head, that pin's head would, on the same scale of magnification, attain a diameter equal to that of the earth's orbit around the sun.

For several years the hope of men of science was to explain all of the activities of the atoms, and so all the activities of nature, in terms of the doings of these two particles, the electron and the proton. The great unification of thought in relation to optics and electricity which followed the epoch-making discoveries of Faraday, Henry, and Maxwell, found in the newly discovered electron a most welcome agent to consolidate the new philosophic structure; for the laws of electrodynamics required that electrons in vibratory motion should emit waves in that hypothetical medium, the ether,



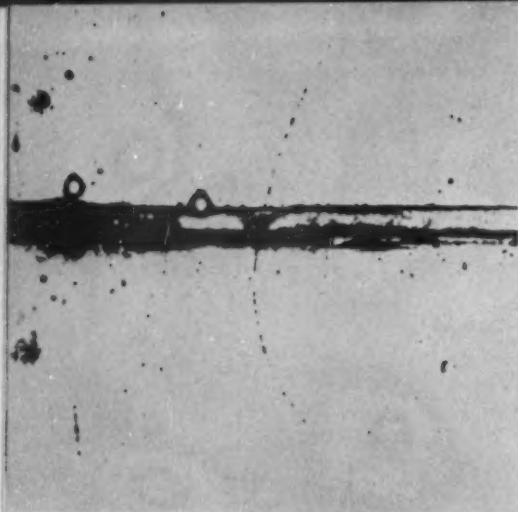
Each of the boxes, A, contains 18 cosmic ray counters arranged as cosmic ray telescopes pointed to different parts of the heavens. Each cosmic ray passage through a telescope is noted by two sets of recorders, one consisting of dials; the other of a line imprinted on moving photographic paper. Relative values for the number of rays coming from different directions are thus secured. B contains the switchboard; control dials are at the top; C, D, and E contain the recording mechanism. S, G, and H were for another purpose concerning simultaneous production of large groups of rays in the apparatus by a single cosmic ray coming from the outside. The apparatus was designed by the Bartol Research Foundation.

so dear to the imagination of the mid-Victorian physicist. Here then, ready at hand, was a mechanism for producing those electromagnetic waves which Maxwell's great electromagnetic theory demanded should be the waves we call light.

The electron picture as an origin for these waves was very alluring. It harmonized with many known facts, and indeed it suggested new possible facts which were sought for and found. But dark clouds began to appear on the horizon of the smooth and apparently brilliantly illuminated sea of knowledge. These clouds grew to a storm calculated to bring disaster not only to the picture of light waves which the electron model had given, but to the very basic structure of the undulatory theory itself, quite apart from its electrical origin.

That undulatory theory had ruled the concepts of science since the time of Newton. It was thought that the battle had been fought in his day and had been won forever. Three hundred years ago Newton suggested that light was caused by streams of particles of some kind shot out from the source of light. However, it was found that this idea would not explain several phenomena which could be demonstrated

with ease, and it seemed to become necessary to suppose that light really consisted of waves in some all-pervading medium, unobservable to our senses, these waves traveling out from the source of light like ripples from a stone thrown into a pond. Different lengths of waves were associated with different colors. The longest of the optical waves were those which gave rise to the sensation of red, the shortest were those corresponding to violet, with waves for all colors of the rainbow between. Then this idea became extended to include waves longer than those which affect our sight, but which could produce heating effects. Then we came to think of wireless waves as simply an extension of this spectrum, as it is called, in the direction of the longer wave lengths. Again, in the direction of waves which are shorter than the violet rays, we saw the possibilities of what are now called ultraviolet rays, which, as you know, have important therapeutic uses. X-rays came to be looked upon as simply a special type of invisible light of still shorter wave length; and some of the rays from radium—the so-called gamma rays—also came into this class with a still shorter wave length. Thus, starting with the wireless waves which may



The picture from which C. Anderson discovered the positron. The dotted track of the particle is made visible by the deposition of droplets of moisture (in the cloud chamber) on the ions created by the charged particle. The upper portion of the track precedes and the lower portion follows passage of the particle through a slab of lead. Deviation of the particle is caused by a magnetic field; the deviation and ionization reveal the charge (positive) and mass of the particle.

have lengths of a mile or more, we came to think of a whole succession of waves ranging through heat, light, ultraviolet light, X-rays, and gamma rays, this succession being one of gradually decreasing wave length, until in the gamma rays we pictured waves so short that a thousand million of them would cover but a third of an inch.

And just when all seemed to be on the way to becoming clear in terms of the beautiful generalization above referred to, the dark clouds of which I have spoken made their appearance in the form of certain experiments which seemed to demand that light waves and X-rays should possess the characteristics of particles. However, in many other types of experiments the spreading-wave idea seemed necessitated. What is it that can on some occasions act like a particle and on others like a wave? The best impression of such illusive things I can give you in a short space is to ask you to think of them as ghosts. A bullet is a kind of thing which can only be at one place at once and which strikes where it is. The electrons and protons are like bullets. A ghost is a creepy kind of thing which you feel can be everywhere always, a thing which only strikes at one place at a time, but which can strike anywhere. These ghosts of physics, these things which represent light, X-rays, and the like, are called *photons*.

And so in the new partnership of negative electrons, protons, and photon ghosts, physics once more hoped that the atomic club was closed; and in the various activities of these three types of members, the hope was to see all of the doings of the universe. It is true that

in the seclusion of their private offices, where their colleagues could not hear their thoughts and chide them for being too bold, many physicists had wondered why there was not a positive counterpart to the negative electron—a thing having the same mass but opposite charge. They had wondered whether there might not be a neutral particle, and doubtless they had wondered many other wicked things. But with some of the older physicists of bygone days still alive and frowning yet at the electron and proton, to say nothing of the photon, they had been more or less ashamed to bring into the limelight such unconventional debutantes as their minds had conjured up. Yet the electron, the proton, and the photon, worked to death by so much responsibility, showed increasing evidence of lacking enough pep to run the universe and, in fact, to take charge of the ever-increasing multitude of experimental facts. They had a kind of dance which they could perform, a dance which they did well and in which they had gained their great reputations, but they did not find themselves able to co-operate with any degree of elegance in any new styles of dance such as were required by the new experimental phenomena. Only after witnessing the shows put on by the electrons, protons, and their companion ghosts, the photons, for such a long time that he was sick of it, did the physicist go out searching in the atomic world and find a new particle, a neutral particle, the *neutron*.

This seemed to give courage to other candidates for entrance into the club of atomic physics. There came the *positron*, the positive counterpart of the negative electron, heralded beforehand by a list of his credentials as supplied by the mathematical physicists, who claimed to know what he would look like when he was found. They were aggravatingly right. Before very long there came, as

a matter of fact through the study of cosmic rays themselves, still another particle which could have a charge of either sign and which possessed a mass 200 times that of an electron. This particle also was preceded to some extent by its credentials in the form of the theoretical predictions of a Japanese physicist, Yukawa. So recent is this particle that the powers that be are yet quarreling over its christening. By some it has been called a "heavy electron," by others a "Yukon," a "barytron," a "mesotron," and the latest name is a "meson."

Now most of these particles came out about the time of the New Deal, and it was found that when they started to operate, the bank accounts didn't balance in the matter of conservation of energy. There was, in certain processes, an apparent disappearance of energy which could not be accounted for in known ways, so there was invented another particle, a *neutrino*, to provide the thief who stole the energy. Physicists have been trying to catch this thief and at least fingerprint him. However, he is a very illusive scoundrel and leaves no trail. In fact, he never seems to do anything with his ill-gotten gains. If he were a human being one might wonder why he stole anyhow, since he presents no evidence of enjoying life in the atomic world. He is nothing but a miser. He has never been known to do anything but own energy. He is the supreme representative of the radical's idea of a capitalist.

As we shall see next month, it is of interest and importance to cite the more outstanding characteristics of these particles of atomic physics, and particularly to trace the development of our knowledge of those characteristics, because that development has run parallel to the growth of our knowledge of the cosmic radiation.

(Continued next month)

## ASTRONOMICAL ANECDOTES

### NEWTON, BLACKLOCK, AND A NEW LARGE TELESCOPE

**A**MONG my notes I find this: "Newton like the modern Major-General," which obviously refers to the song late in Act I of *The Pirates of Penzance*.

*I'm very well acquainted too  
with matters mathematical,  
I understand equations, both the  
simple and quadratical,  
About binomial theorem I'm  
teeming with a lot o' news—  
With many cheerful facts about  
the square of the hypotenuse.*

Henry Sotheran, Ltd., had for sale for about \$2,000 a copy of Euclid, in Latin, full of manuscript notes in Newton's handwriting. As Sir David Brewster related in his *Memoirs of Newton's life*, it was about July, 1661,

that Newton purchased an English Euclid, so he could understand the diagrams in a book of astrology he had bought at Stourbridge Fair. He found the truths of the propositions in Euclid so obvious that he put aside the study of geometry, more or less in disgust; he was very fond of Cartesian geometry, which we call analytic, because it provided more stimulation to his mind.

Later he found that the fundamentals he should have gained from Euclid left a serious hiatus in his knowledge and he regretted that he had "applied himself to the works of Descartes, and other algebraic writers, before he had considered the elements of Euclid with that attention which so excellent a writer deserved." He purchased a Latin



Euclid and read it with great care, expressing himself as particularly pleased with the propositions on the equality of parallelograms erected on the same base, between the same parallels.

It seems strange to us to reflect that even the mathematical mind of Newton should have been repelled by Euclid, like that of the average high-school sophomore, though for a different reason. But he was fortunate to discover his mistake later; many astronomical amateurs are not so acute, when they try overnight to know all about the expanding universe without first knowing what the Doppler effect is, or the way the spirals are put together. If every amateur could be convinced that the best book for him to buy is a college textbook in astronomy, to be read through carefully from cover to cover, he would be very grateful not to have kept on reading the "popular" books, full of clever writing and less precise information. In most instances, such books are better read by professionals than by amateurs.

I've recently bought a book for less than two dollars that I hope will *not* be the first book read about astronomy by anyone. I bought it for a specific purpose; it contains a complete translation of the *Phaenomena* of Aratos, made by Robert Brown, Jr., in 1885. The book has other good features, too, despite its having been published by an astrological house; any amateur who knows enough not to be swayed by a great amount of utter nonsense disguised in pseudo-scientific verbiage, who wants a good translation of Aratos, some of Manilius, a reproduction of Burritt's *Atlas* and other good material, can write me for the name of the book and the place where it is sold.

Glancing back at the third paragraph above, I wonder if Newton was particularly interested in propositions involving parallelograms because of his work in resolving forces into vectors. And that reminds me of the comment by Augustus De Morgan when he ran across a catalogue reference to a book by J. C. Schwab on a "new theory of parallels, in eight volumes." "Surely," said De Morgan, "this is a misprint; *eight* volumes on the theory of parallels? If there is such a work, I trust I and it may never meet, though ever so far produced."

An unexpected visit from a gentleman from Chicago, who when very young visited at the Yerkes Observatory, reminds me of the occasion when the secretary there received a phone call from Chicago, asking that Prof. Frost be called. The secretary replied, "Prof. Frost is out at the Snow telescope with Prof. Hale and Dean Gale." It was a stormy day at Williams Bay!

The Snow telescope, the first great solar instrument, was later moved to

(Continued on page 9)

# Amateur Astronomers

## ASTRONOMICAL INFORMATION PLEASE

A program of astronomical information was conducted at the March meeting of the Amateur Astronomers Association of Pittsburgh. It was so thoroughly enjoyed and proved so profitable as a means of instruction that the program committee has established it as, at least, an annual event.

Dr. I. Q. Fred Garland, the quizmaster, posed questions selected from those submitted by members beforehand. Two teams of four quiz kids each occupied chairs before the audience. Willard MacCalla, Robert Melnick, G. W. Ulrich, and Roelof Weertman opposed Eugene Opp, Leo Scanlon, Don Sieber, and Louis Bier. The questions were alternated between the two teams, and for answering a question correctly, the team received 10 points. If no correct answer was forthcoming, the other team received five points for the correct answer.

"What are the names of the constellations of the zodiac?" was the first question. MacCalla's team was stumped after naming seven. The other team came through with four more. The quizmaster scolded Leo Scanlon for his failure to realize that the latter's namesake was the 12th.

Questions were asked and answered with dispatch and fun. It is safe to say that everyone went away with an enhanced knowledge of astronomy.

LOUIS E. BIER, secretary  
A.A.A. of Pittsburgh

## GOOD NEIGHBORS

The speaker before the Detroit Astronomical Society for May is Cyril Hallam, a graduate of the University of Saskatchewan, and now instructor of physics at the Patterson Collegiate Institute, Windsor, Ontario. Mr. Hallam is a member of the Astronomy Study Club of Windsor, which gathered last October and now has about 35 members who carry out an ambitious program. The Detroit and Windsor groups enjoy fulfilling the good neighbor policy monthly, and benefit therefrom.

Mr. Hallam is speaking on May 14th at Wayne University at 3 o'clock, and his lecture on "Becoming Acquainted with the Zodiac and the Spring and Summer Skies" is designed to guide beginners in intelligent enjoyment of the warm evenings which lie ahead. Guests are welcome.

Members of the Detroit group are planning to get together around telescopes to observe the occultation of Jupiter on April 30th, at 3:00 p.m.

## AMATEUR ASTRONOMERS ASSOCIATION New York City

An observation meeting of the Amateur Astronomers Association is scheduled for Wednesday, May 3rd. Meet at 8 o'clock, Room 129, Roosevelt Memorial Building, American Museum of Natural History.

The annual meeting of the association, featuring motion pictures, reports of officers and committees, and entertainment, will be held on Wednesday, May 17th, at 8:00 p.m. at the museum. The meeting is open to the public.

## THIS MONTH'S LECTURES

*Cincinnati:* On Friday, May 12th, there will be a special Observatory Night, exclusively for members of the Cincinnati Astronomical Association, featuring use of the 8-inch telescope, and convening at 8:00 p.m. The society's observatory may be reached by Cleves-Louisville pike; turn right on Zion Road, two miles to the observatory.

*Cleveland:* "Invisible Glass and Telescopes" will be the subject of the talk before the Cleveland Astronomical Society on May 26th at 8 o'clock, by Dr. R. C. Williams, of the University of Michigan Observatory.

Public nights are scheduled for May 4th and 5th, when a lecture on "The Distances of the Stars" will be given at 8:30, followed by observation. Reservations may be had through the Case School of Applied Sciences, GARfield 6680. These and the society lectures are held at the Warner and Swasey Observatory.

*Philadelphia:* On Friday, May 12th, Dr. Dorrit Hoffleit, of Harvard College Observatory, will speak to the Rittenhouse Astronomical Society on the subject, "What Falls From Heaven." The meeting will be held at 8:00 p.m. at the Whittier Hotel, 15th and Cherry Streets.

*Pittsburgh:* "Sightseeing Among the Stars" is the title of the talk by Willard A. MacCalla before the Amateur Astronomers Association of Pittsburgh on Friday, May 12th. The meeting is held at the Buhl Planetarium, at 8:00 p.m.

*Washington, D.C.:* At the meeting of the National Capital Amateur Astronomers Association on May 6th at 8:00 p.m., at the National Museum, Dr. W. J. Eckert, director of the Nautical Almanac Office, will speak on "Almanacs for Land, Sea, and Air, and How They Are Made."



ON THE 14th of December, 1943, the warship *Querétaro* left the quiet waters of Acapulco carrying the Mexican scientific mission which was to observe the total eclipse of the sun on January 25th, in Peru. The group consisted of Dr. Joaquin Gallo, director of the National Observatory at Tacubaya and leader of the expedition, Eduardo Gallo and Luis Zubieta from Tacubaya Observatory, and José Alva and the writer from the National Astrophysical Observatory at Tonanzintla. Pedro Montejo and Hugo Cuesta Jara, both from the Naval Department, collaborated in the observations. Three newspaper reporters contributed to the variety of the group. We were particularly glad to be in the company of 45 cadets of the Navy, for we were to sail leisurely to allow them ample opportunity for practice.

The expedition was initiated by Director Luis Enrique Erro, of the Tonanzintla Observatory, and Governor Gonzalo Bautista, of the State of Puebla, and organized jointly by the Tacubaya and Tonanzintla Observatories. Through the courtesy of President Manuel Avila Camacho funds were generously provided by the Mexican government. The president thus once more showed his interest in the scientific undertakings of this country. It may be recalled that he presided at the inauguration exercises of the Tonanzintla Observatory two years ago (see *Sky and Telescope*, April, 1942).

The Department of the Navy had taken all possible measures to insure us a comfortable trip. We appreciated deeply the courtesy shown us by the commander and officers of the *Querétaro*. Lt. Montejo sailed with us to look after the special needs of the expedition members and also took charge of the



Members of the Mexican expedition were, left to right, standing: Lt. Montejo, Dr. Gallo, Eduardo Gallo, Messrs. Jara, Alva, and Zubieta; in the foreground at left, the author. The photos on these pages are by courtesy of Dr. Gallo.

## Mexican Eclipse Expedition

BY FELIX RECILLAS J.

*National Astrophysical Observatory, Tonanzintla*

chronometers and read the seconds during totality.

The thrill of being on a warship made us forget for a moment what a total solar eclipse had in store for us; we were enjoying the adventure of the sail through tropical waters. All throughout, however, we regretted the absence of Director Erro, who had given up the trip to attend to affairs at Tonanzintla Observatory.

At dawn of January 3rd, the fabulous Andes were observed encircling the horizon. They became steadily more majestic as the ship approached the land of the Incas. The *Querétaro* greeted Peru with the conventional 21-gun salute. We anchored at Callao, where we were welcomed by the ambassador of Mexico, Col. A. Tejeda. Two pleasant days were spent in Lima where the party had the pleasure of dining with the ambassador. We also visited the Universidad Mayor de San Marcos where the writer was very happy to meet among others Dr. Godofredo Garcia and Dr. Alfred Rosenblatt who did not hesitate to express their interest in scientific activities in Mexico.

Astronomers and instruments then traveled some 750 miles by bus northward to Chiclayo, a city of about 35,000 inhabitants. The road runs along the

sandy shore of the ocean. The place was selected on the basis of weather reports kindly communicated by the National Geographic Society, and which indicated Chiclayo to be more favorable than Cajamarca.

In Chiclayo, the yard of the primary school was put at our disposal and there we installed our instruments. Through the courtesy of the prefect of Lambayeque all the material needed for the construction of pillars and housing was supplied. There was plenty of time for the mounting and adjustment of the instruments. The co-ordinates of the site were provided by the astronomical department of the university in Lima; Dr. Gallo's determination showed the necessity of a slight correction; the final result gave  $79^{\circ} 51'.5$  west,  $6^{\circ} 46'.9$  south.

Our equipment consisted of:

A 15-cm. Grubb refractor, equatorial mounting, with electric drive and adaptable camera where the polaroid was mounted.

A coelostat with three mirrors.

Two cameras of 8 and 19 meters focal length, respectively, to be used with two mirrors of the coelostat.

A Ross-Fecker 3-inch camera and many other minor pieces of apparatus. The sky was mostly cloudy at night



Throughout the partial phases of the eclipse the projection of the sun's image through the 19-meter camera attracted many visitors. The image was nearly seven inches in diameter.

(22 cloudy nights in 26 days); we were content with a glimpse or two of the interesting objects of the southern sky. However, the group had the opportunity to partake in the social activities Chiclayo could offer and to make Peruvian friendships.

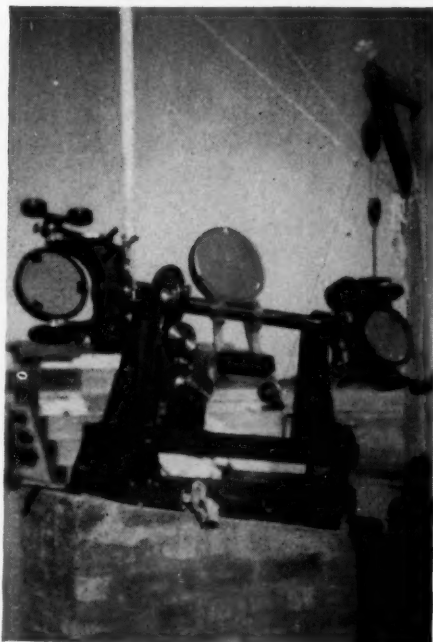
January 25th proved to be an undeclared holiday. Our camp was honored by the Peruvian ministers of education, of foreign affairs, of war, and agriculture. Many officials and individuals from all parts of the country had arrived to watch the eclipse (and consequently, the Mexican astronomers, too). It was a day of celebration. The atmosphere was filled with the buzz of the crowd and, as usual during an eclipse, the tension was high!

When first contact took place at 7:56 a.m., not the smallest patch of cloud was to be seen. At the approach of second contact (beginning of totality) we were at our posts with throbbing hearts. The writer was glad that he could see the totality while counting seconds for his exposures. He, too, thought that a total eclipse of the sun—this was the first he had seen—was a dramatic spectacle, a magnificent one indeed. After more than 2 2/3 minutes, totality was over and with third contact the tension of both astronomers and spectators vanished.

About 85 per cent of the planned program was carried out successfully. Direct photographs were obtained of the corona with the two long-focus cameras and the 3-inch camera. The cover picture of this issue is a 30-second exposure with the 8-meter camera. A motion picture of the beginning and the end of totality was also obtained.

The writer was in charge of the 15-cm. equatorial, which was devoted to the study of the polarization of the coronal light. This program was planned and

The coelostat ready to be used.



A group of people at the eclipse camp the morning of January 25th.

the polaroid provided by the Harvard Observatory. [Dr. Gallo notes that the polar feathers or aigrettes are very conspicuous on the photos with the polaroid.]

During the few days following the eclipse we packed for our return. On the way to the anchored *Querétaro*, after bidding goodbye to our Peruvian friends, we were happy to realize that we had gained far more than that which even a total solar eclipse had offered us.

### TIMES OF TOTALITY REPORTED BY LIMA

Late in March, the astronomical news bureau at Harvard Observatory received a communication from Dean Godofredo Garcia, of San Marcos University in Lima, transmitting the results of observations by Dr. Alfred Rosenblatt and Juan M. Portocarrero. Their observations of the eclipse were made at the observatory in the Colegio San José in Chiclayo, not far from the site of the Mexican expedition.

The important moments for timing an eclipse by visual means occur when the contacts are made. It is very difficult to time first contact precisely, for the dark moon is not evident until it has already encroached some distance on the sun's disk. On the other hand, second contact, when the moon completes its job of covering the sun's brilliant disk, is considerably easier to time because then the last ray of sunlight is hidden by the moon just as if a camera shutter had been closed. Nevertheless, phenomena such as Bailey's beads, the diamond ring effect, produce uncertainties in timing both second and third contacts.

The predicted time for second contact, according to the calculations of the Lima astronomers, was 14<sup>h</sup> 7<sup>m</sup> 33<sup>s</sup>.6, universal time. Their observations showed the total phase to begin at 14<sup>h</sup>

7<sup>m</sup> 34<sup>s</sup>.25, or slightly later than predicted. Third contact, the end of totality, was predicted for 14<sup>h</sup> 10<sup>m</sup> 20<sup>s</sup>.9, but observed at 14<sup>h</sup> 10<sup>m</sup> 18<sup>s</sup>.53, or nearly 2½ seconds earlier than expected. The total observed duration of totality was thus 2<sup>m</sup> 44<sup>s</sup>.3, or some three seconds shorter than the calculated time of 2<sup>m</sup> 47<sup>s</sup>.3. The Lima position is given as 79° 51' 23".42 west, 6° 47' 15".10 south, altitude 28.57 meters.

In a letter to Harvard, Dr. Joaquin Gallo, leader of the Mexican expedition and director of Tacubaya Observatory, writes: "My computation of the duration of totality gave 2<sup>m</sup> 42<sup>s</sup>.5; the real count was 2<sup>m</sup> 40<sup>s</sup>.5. I cannot explain the difference with the computation of Peruvian astronomers."

Perhaps some of the discrepancy is to be found in the difference in the positions used by the two groups of observers, amounting to 21" of latitude and 6".58 of longitude.

### ASTRONOMICAL ANECDOTES

(Continued from page 7)

Mount Wilson; I believe it is no error to say its work has largely been superseded by that of the tower telescopes at the same institution. And now that we've got ourselves to Mount Wilson, I can pass along a bit of information that I have often wanted to have myself. I recently found that it was Dr. A. Woolsey Blacklock who, in a letter written in 1876, suggested that a third mirror could be used to turn the beam from the Cassegrainian secondary to the side of the tube, to avoid having to perforate the primary mirror. In most textbooks where this three-mirror optical arrangement, exemplified in the 100-inch and 60-inch reflectors, is mentioned, it is spoken of as a modified Cassegrainian. I think it only fair to refer to it hereafter as the Blacklock arrangement.

And if the editor will let me have about 10 more lines, I'd like to announce, with just a little regret, that the palm for the largest completed telescope has passed from the United States to France; according to a report in the *Astrophysical Journal* for January, 1944, a 120-inch reflector was installed but not yet in operation, as of October, 1942, at the new astrophysical station in Haute Provence.

R. K. M.

### CORRECTION

The editors were in error in the title assigned to Dr. W. Carl Rufus, author of the article on "The Challenge of the Rainbow," in the April issue. Dr. Rufus writes that the regents of the University of Michigan conferred on him "the title of Acting Chairman of the Department of Astronomy with all the rights and privileges pertaining thereto, including the responsibility associated with the title, Director."





Sherburne Wesley Burnham,  
from an informal snapshot  
made by Dorothy Wallace  
in 1908.

# From Back-yard Astronomy to the Annals of Fame — BURNHAM

BY CLARENCE R. SMITH

*Aurora College*

*Objects for Common Telescopes*, and in fact it was doubtless this book which eventually turned his attention specifically to double stars. Photography also came into his sphere of interests, and this alone brought him quite a little recognition in photographic circles. At one time he won a prize for a speed photograph of a cat in the act of jumping after a bird. This was regarded at that time as a noteworthy example of instantaneous photography.

Burnham's home in Chicago happened to be within a few blocks of the old Dearborn Observatory, then of the University of Chicago. This observatory had raised funds by popular subscription and purchased from the Clarks a fine 18½-inch object glass. We can readily imagine the keen interest with which the alert and astronomically minded Burnham watched proceedings as he made occasional visits to this observatory.

When the Clarks passed through Chicago in 1869 after their trip west to observe the eclipse of the sun in January of that year, Burnham visited them at the observatory and asked them what they would take to make him a 6-inch object glass of the finest their skill could produce. They set the price at \$800 and he placed the order. This lens is said to have been one of the finest the Clarks ever made and Burnham himself, after extensive use of it, described it as "simply perfect."

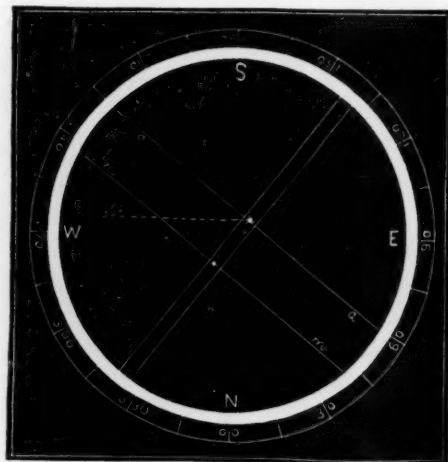
**T**HE INTENSIVE and lifelong pursuit of what was during most of his life only a hobby, on the part of the subject of this sketch, meant a greater contribution to the cause of science than the professional life of many a man whose science is his bread and butter. The world will scarcely know that Sherburne Wesley Burnham was by regular occupation a courtroom reporter, but his catalogue of double stars will go down in the history of astronomy as the greatest monument of its kind, probably for all time. By the middle of the 19th century it was generally concluded that the Herschels and the Struves with the greatest telescopes of the day had practically exhausted the field of discovery of double stars. Little was it supposed that the greatest number of double stars ever to be discovered by one man would yet be revealed, and a good portion of these with a 6-inch telescope with a largely homemade mounting, in a Chicago back yard.

Burnham was born at Thetford, Vt., on December 12, 1838. His graduation from the Thetford Academy marked the end of his education as far as formal schooling was concerned. But little has been recorded regarding his early life, although it is known that as a young man he became interested in shorthand writing and developed considerable proficiency through home practice. In about 1857 or 1858 he went to New York, probably in the interests of study or employment with shorthand.

During the Civil War we find him

stationed with the Federal Army in New Orleans as a shorthand reporter. At the close of the war he journeyed to Chicago and became an official reporter for the U.S. circuit court, which position he was to hold for the next 20 years, or more. During this period, in addition to his regular daytime occupation, he carried on a program of astronomical observations in his little observatory at night. In 1868 he married Mary Cleland, and they took up residence on Vincennes Avenue near Ellis Park in Chicago. The family eventually came to include three sons and three daughters.

Burnham's first interest in astronomy came about almost by accident. While a young man in New Orleans, he chanced to be passing a bookseller's shop while an auction was being held, and out of curiosity he stopped at the door just as the auctioneer was shouting, "Burritt's *Geography of the Heavens*!" For no very good reason he bid a small sum for the book and the auctioneer handed it down to him. Upon taking it home, he became interested enough to try to find in the night sky some of the objects described and mapped in the book. Further interest prompted him to buy a cheap telescope and soon after, a better one, which he took to Chicago with him in 1866. It should be related that he also became interested in the use of the microscope, but this hobby he finally relinquished in favor of astronomy. Still further stimulus was given his astronomical interests by his acquisition of a copy of Webb's *Celestial*



A micrometer with a field such as this is used for the measurement of positions and motions of double stars.

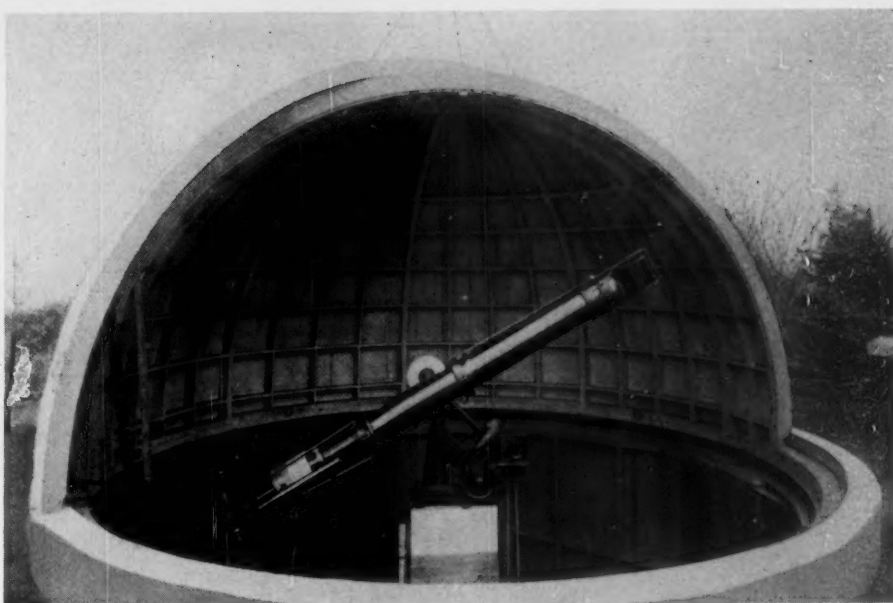


With it he discovered something like 400 double stars, many of them very difficult for any instrument.

The mounting for this telescope was largely homemade and lacked many of the refinements to be found in the large observatories, yet it admirably answered the purpose for which it was used. There was no driving clock to compensate for the earth's rotation, but a similar result was accomplished by a lead weight resting on the surface of a quantity of sand in a large cylinder. As the sand leaked out of a hole in the bottom of the cylinder in hourglass fashion, the lead weight slowly descended and gave a steady forward motion to the telescope. The little observatory which was erected in Burnham's back yard to house the instrument came to be known by the neighbors as the "cheese box" in which Burnham spent most of his evenings.

In 1873 he compiled a list of the double stars he had discovered to that date and sent it to England for publication in the *Monthly Notices* of the Royal Astronomical Society. This was his first published catalogue. For several months during 1876 and 1877 he served as acting director of the Dearborn Observatory. In 1888 the Lick Observatory was opened, and Burnham was invited to serve on the staff as an astronomer. Although at considerable financial sacrifice, he accepted the position and moved westward with his family. Then for a period of several years his hobby became a profession. However, in June of 1892, he resigned and returned to Chicago. In 1894 he was awarded a gold medal by the Royal Astronomical Society. During a period of five years beginning in 1897, he acted as receiver for the Northern Pacific Railway. Also in 1897 he began making weekend visits to the Yerkes Observatory and was recognized as senior astronomer there until his retirement in 1914.

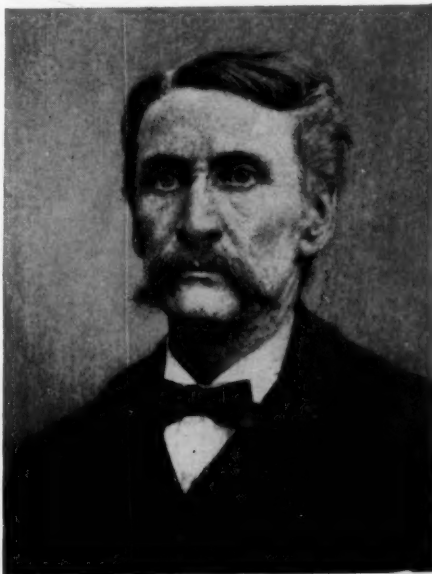
Although Burnham had published several catalogues of his double stars in various publications, there appeared in 1900 a much greater work than any of these. This was his *General Catalogue of 1290 Double Stars* (discovered by him from 1871 to 1899), Volume I of the *Publications* of the Yerkes Observatory. As he continued his work at Yerkes, there soon accumulated other discoveries and hundreds of measurements and in 1906 the greatest monument of his life was completed: the *General Catalogue of Double Stars*, published by the Carnegie Institution of Washington. This is in two volumes, the first being the catalogue proper, and the second, notes to the catalogue. Further work was published by the Carnegie Institution in 1913 as *Measures of Proper Motions of Stars, Made with the 40-inch Refractor of the Yerkes Observatory, 1907-1912*. During his



Burnham's fine 6-inch lens was later remounted in the Students' Observatory of the University of Wisconsin. George C. Comstock, then director of Washburn Observatory, used this telescope in an investigation of the aberration and atmospheric refraction. In order to observe simultaneously stars 120° apart in the sky, he reconstructed the dome and placed three mirrors on a reel in front of the objective. Washburn Observatory photo.

entire life he is credited with the discovery of 1,340 double stars.

Burnham was a man of great modesty. On one occasion some of his associates in the circuit court were quite astonished to find that Burnham, the Chicago astronomer who had acquired some public notoriety, was none other than the man with whom they had been associated for years in the courtroom. He was in excellent health until late in life and had very acute vision. He enjoyed long tramps in the mountains of California and in the woods of Michigan and Wisconsin. He always carried his camera and rifle and was an expert in the use of both. His death occurred March 11, 1921.



An engraving of Burnham, from the "Century Magazine," 1889.

The 18½-inch telescope of the old Dearborn Observatory was eventually acquired by Northwestern University and has now for many years been in use in the newer Dearborn Observatory on their campus in Evanston. The famous 6-inch lens used by Burnham for many years was acquired by the University of Wisconsin and was installed in new mountings in their Washburn Observatory. The original wooden tube used by Burnham with the 6-inch glass is now part of a splendid exhibit of Burnham instruments and mementos in the Adler Planetarium and Astronomical Museum in Chicago. Among other articles in this exhibit are a volume of manuscript copy of the *General Catalogue*, a circular slide rule designed and computed by Burnham and constructed for him by Warner and Swasey, and a number of other instruments such as an aneroid barometer, a planimeter, and a protractor. At present there are also in the exhibit two gold medals and other articles loaned by members of the family who still live in Chicago.

In preparing this sketch the author has used especially the following references and the reader would do well to consult them if he wishes to pursue further the life of Burnham:

Burnham—*General Catalogue of 1290 Double Stars, Publications* of the Yerkes Observatory, Vol. I, 1900.

See introduction for historical notes. Dugan—"Sherburne Wesley Burnham," *Dict. of Amer. Biog.*

Fraser—"An American Amateur Astronomer," *Century Mag.*, June, 1889.

Frost—"Sherburne Wesley Burnham, 1838-1921," *Astrophysical Jour.*, July, 1921.

# COMETS AND M

BY MARIAN

*Here and in the Hayden  
story of comets and their*



Halley's comet at its 1910 appearance.

**T**HE WORD *comet* is derived from a Greek word meaning long-haired.

Because of the extensive and brilliant tails which accompany some comets on their journeys around the sun, the early stargazers thought this an appropriate name.

Whenever extremely bright comets have appeared, men have gazed at them overcome with awe and wonder. Superstitions have grown up, as they always have about little-understood natural phenomena, and comets through the years have been regarded as omens—sometimes good, and sometimes bad—but always of great import. The Roman historian, Suetonius, writes as follows of a bright comet that appeared at the time of Caesar's death in 43 B.C.:

"A hairy star was then seen for seven days under the Great Bear. . . . It rose at about five in the evening, and was very brilliant, and was seen in all parts of the Earth. The common people supposed that the star indicated the admission of the soul of Julius Caesar into the ranks of the immortal gods."

Shakespeare, in the play *Julius Caesar*, writes:

*When beggars die, there are no  
comets seen,*

*The heavens themselves blaze forth  
the death of princes.*

Comets move around the sun, probably in highly elongated paths, although some of their orbits have in the past

been considered, probably erroneously, to be parabolic or slightly hyperbolic. It is generally assumed, however, that their orbits can be regarded as elliptical, which would place them immediately within the sun's family. If the paths were actually parabolic, these visitors would come into the neighborhood of the sun from interstellar space, and then pass out into interstellar space again, never to return. Because of the extreme difficulty in determining the exact paths of these "doubtful" comets, most astronomers assume that they are members of our solar family, coming back periodically to the neighborhood of the sun.

A comet is composed of three main parts. The nucleus is bright and small, and appears almost starlike. Enveloping the nucleus is the coma, which appears like a misty fog surrounding it. The tail of the comet, which in some cases is lacking altogether, is to the layman the most interesting feature. Sometimes the tail attains an enormous length, many millions of miles. One interesting fact about the tail of a comet is that it always points away from the sun, as though the comet were a courtier keeping his back and his flowing train turned politely away from the royal king of the sky. As the comet sweeps in toward the sun, the tail follows along as one would expect a tail to behave, but as the comet moves around the sun, the tail sweeps sideways, always pointing directly away from the solar body. It is believed today that the tail is caused by the radiation pressure of sunlight, on gases and dust in the head of the comet.

Occasionally the earth will pass through the tail of a comet, but no harm results, as the tail is actually a vacuum emptier than any that we can produce upon the earth. Early this century, the earth passed through the tail of Halley's comet, but most people did not know anything about it. The only possible effect noticed may have been a slight increase in sunset colors, though this is not certain.

Some comets have neither nuclei nor tails, and can be seen only as faint, fuzzy spots of light. They could sometimes be easily mistaken for nebulae, except for their distinguishing motion across the sky.

A very common error concerning comets is the belief that they shoot across the heavens, with a bright flash lasting but a few seconds. Such objects are properly called meteors. Comets are usually visible for many nights or weeks, growing brighter as they approach the sun, and then fading away as they travel out into space. The nightly movement of most comets would hardly be

discernible to the average observer.

One of the most interesting comets is Halley's, which last appeared in 1910, and which has a period of 76 years. Its next bow will be taken in 1986. Many people remember it, because of the great publicity attending its advent, as the bright comet they saw in 1910. Actually, another brilliant comet which appeared in 1910, Comet 1910a, could be seen in the daylight and developed several tails. Halley's comet, however, is one of the most interesting for many reasons. It was the first comet whose periodicity was established. Also, its history can be traced back more or less accurately for about 2,000 years, to an appearance recorded by Chinese astronomers in 240 B.C.

Halley, in predicting the return of the comet which came to be called by his name, was courageous in the extreme, for his reputation rested on the accuracy of his observations and calculations. He predicted in 1705 that it would return in 1758, just 76 years after its previous

Comet Morehouse 1908.





# METEORS

MARIA LOCKWOOD

ayden metarium this month, the  
their nives, the meteors, is told.

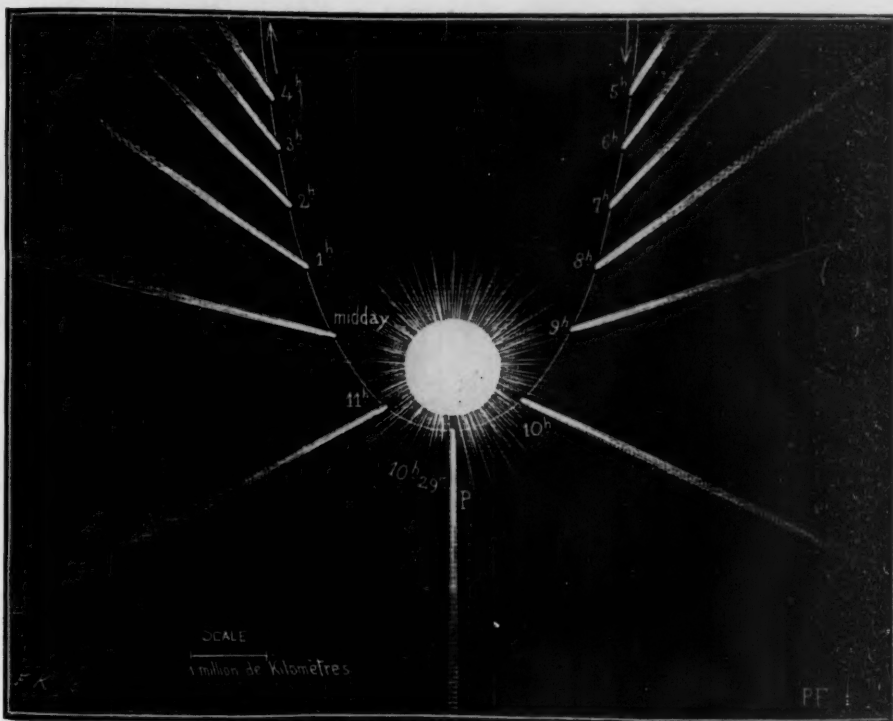
appearance. Halley himself died in 1742 so he was never able to check up on his own prediction. The comet did indeed come back at the time indicated and was discovered on Christmas night, 1758, by an amateur astronomer near Dresden. It reached perihelion (nearest the sun) the next year, in 1759, on March 12th. The return of Halley's comet not only vindicated Halley's calculations, but proved that Newton's laws fitted the motions of these bodies as accurately as those of the planets.

Another interesting comet is Encke's, which is due to return this summer. This is not as epoch-making an event, however, as Encke's comet has a very short period, only 3.3 years. It was last seen in 1941, appearing as a very faint nebulous object of about 17th magnitude, obviously not visible to the average observer. There is no comet known with a shorter period than Encke's. When it appears in July of this year it will again be of much less than naked-eye visibility. Rarely does it become bright enough to be seen without optical aid. Now and again one runs across the statement that Encke's comet is as bright as when first seen, in 1786. This statement is not strictly true, however, as the comet has become fainter by one magnitude a century, and eventually will not be visible even through the largest telescopes.

One question which is frequently asked about comets concerns their origin. And this is a question which no one can answer. There are various theories, but none of them is wholly acceptable to the careful astronomer. As Fletcher G. Watson says in his book, *Between the Planets*, "Perhaps we should be very honest and say that we do not know how, when or where comets were formed."

Meteors are commonly known as "shooting" or "falling" stars, although they are not stars, but tiny particles of matter. Sometimes they are stony in character, and sometimes metallic. As they collide with the atmosphere of the earth they come hurtling down through the air at speeds of many miles per second. During this rapid trip through the atmosphere, friction with the air causes the meteor to glow and the gaseous trail to become incandescent. This causes the flash of light we see when we observe a "shooting star."

Most meteors are not much bigger than grains of sand and bodies of this size are destroyed before they reach the earth's surface. Larger meteors like the



A comet's tail always points away from the sun.

Ahnighito, which weighs 36½ tons, survive the trip through the air and land on the surface of the earth. A meteor when it comes to earth is called a meteorite.

The word *meteor* means, in the original and strictest sense, anything which occurs in the atmosphere. Clouds, therefore, or any other atmospheric effects could be called by this name. Hence the word *meteorology*, which has to do with the weather and atmospheric effects but not at all with the study of meteors.

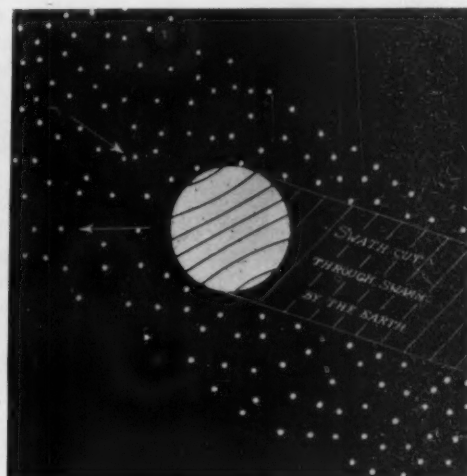
On almost any clear night the observer is likely to see several meteors flashing across the sky, and disappearing almost as soon as seen. These are sporadic or occasional meteors which do not belong to the beautiful meteor showers which come at definite times of the year. Among these showers the Leonids, which come in November and appear to originate in the constellation Leo (although this is only the effect of perspective), and the August Perseids are the best known and most beautiful. At present, however, the Leonids are faint and sparse, and surpassed by such showers as the Orionids and Geminids.

These showers occur when the orbit of the earth crosses the orbit of one of the great meteor swarms that move around the sun as do the planets themselves. It is interesting to note that so far as we know no meteorites have ever been discovered which can be definitely identified as having fallen during a meteor shower.

Meteors are not usually seen at heights greater than 100 miles above the surface of the earth, or less than 30 miles.

Metallic meteorites are most often composed of about nine-tenths pure iron with some nickel mixed in. Small quantities of other metals are also found. The iron of metallic meteorites can be distinguished from terrestrial iron by etching with nitric acid. In this etching process the real meteoric iron shows up a peculiar crystalline pattern known as the Widmanstaetten lines, which are almost never found in terrestrial iron.

While the origin of meteors as a class is not much better understood than the origin of comets, it is interesting to note that the elliptical orbits of some of the meteor swarms correspond identically with the orbits of comets which have been observed in the past. It is believed probable that some of the meteor swarms are the result of the disintegration of comets by their constant close approaches to the sun.



The earth is a catch-all for meteors.



# BEGINNER'S PAGE

## MAN AND HIS EXPANDING UNIVERSE — VI

IN THE "dark" period between Ptolemy and Copernicus there were a few bright spots. Albategni, a prince of Syria, made many observations and prepared astronomical tables that were more accurate than those of Ptolemy. He also determined the eccentricity of the solar orbit and the rate of the precession of the equinoxes more precisely, and he stated that the place of the sun's "apogee" was not fixed.

Ulugh Bey, a prince of Tartary, founded an astronomical academy and made many personal observations. Among the instruments he had constructed was a gnomon 180 feet high. The results obtained compare favorably with those made later by Tycho Brahe. A catalogue of fixed stars prepared under the patronage of Ulugh Bey ended the gap of 16 centuries that had elapsed since Hipparchus produced the first list.

In the 15th century, Purbach and his pupil, John Mueller, translated and corrected the *Almagest* and other ancient treatises. Mueller and Walther established an observatory in Nuremberg with unique instruments; they used the recently invented clock to determine the times of their observations. John Werner of Nuremberg suggested the method of determining longitude by measuring the distance between the moon and fixed stars, a procedure that was so brilliantly used by Bowditch in his remarkably accurate navigation so

many years after its innovation.

Handicapped, however, by the belief that the earth was the center about which the universe revolved, astronomy remained dormant until its shackles were removed by Copernicus when he re-proclaimed the theory of Aristarchus that the earth and the other planets revolved about the sun.

Copernicus showed that a daily revolution of the earth on an axis inclined to the ecliptic explained the apparent motion of the stars. He still clung to belief in the uniform circular movements of the planets, and in order to explain their observed motions was forced to the hypothesis that the center of each orbit was different and did not coincide with the position of the sun. Nevertheless, the simplicity of his universe helped to establish its probability in the minds of men.

Tycho Brahe (1546-1601), the Danish astronomer, fortunately had the means to provide himself with the best instruments of his time. He was a zealous observer and accumulated a mass of accurate observations, including the positions of 777 fixed stars and a series of many years' observations of the positions of the planets and the movements of the sun and moon.

It remained for his disciple, Johannes Kepler, to use this splendid set of observed facts to establish the truth of the orderly universe of which many had

BY PERCY W. WITHERELL

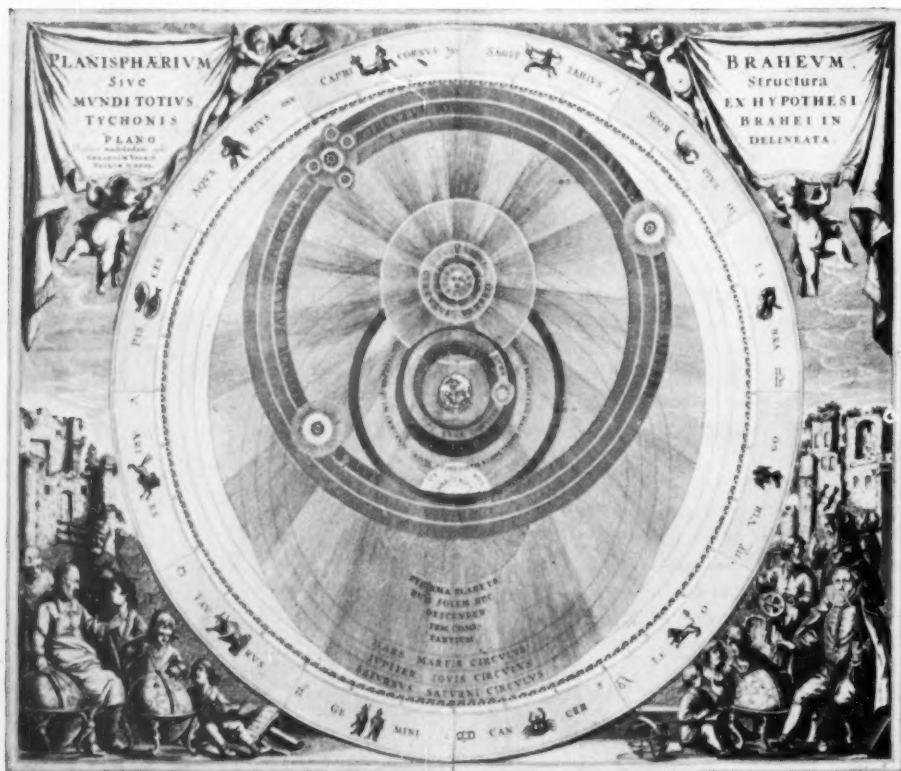
dreamed but were unable to describe. After years of very laborious calculations, Kepler proved that the universally held theory of the circular orbits of the planets was not true, and that their orbits were ellipses with the sun in one of the foci. He then proved that the idea of a uniform rate of motion in the orbits was also untrue. Continuing his calculations he showed that the areas described by the radius vector of a planet are equal for equal times.

Some years later, Kepler also showed that the squares of the times of revolution of the planets about the sun are in proportion to the cubes of their distances from the sun. These three laws of Kepler established a mathematical relationship as a foundation on which to erect the modern astronomical edifice.

Unfortunately, Kepler thought that comets never returned and that it was useless to calculate their orbits. So he missed what would have been a gratifying discovery that many cometary orbits are highly elliptical. Kepler showed a method of determining longitude by the observations of eclipses of the sun. Hearing of the invention of logarithms by Napier, Kepler computed a table of natural numbers, sines and tangents. He suggested a telescope with two convex lenses which was better than the combination used by Galileo. Kepler had some very good ideas as to the nature of gravity. He thought it varied with the size of two bodies, and explained that the attraction of the larger earth prevented the waters that rose in a tide by the attraction of the moon from leaving the earth. Peculiarly, he thought the attraction diminished with increasing distance instead of with its square, although he had shown that the intensity of light varied inversely as the square of its distance from its source.

Galileo, a contemporary of Kepler, had the distinction of revealing to the world the actual revolution of one celestial body about another. When he let people see the moons of Jupiter revolving around that planet, he exhibited a concrete illustration of what to many had previously been only an abstract hypothesis. Everyone knows of his use of the telescope, his bewilderment on observing Saturn, and his discovery of the phases of Venus, and the spots on the sun. Perhaps less well known but equally important was his demonstration of the acceleration of falling bodies and the regularity of the vibrations of a pendulum.

Johann Bayer published maps of the constellations and used Greek letters to mark the stars. From astronomical tables published by Lansberg, Horrox learned of the coming transit of Venus and in 1639 first observed such an event.



In Tycho Brahe's system, the planets revolved around the sun, which in turn revolved around the earth.

# NEWS NOTES

BY DORRIT HOFFLEIT

## GOLD MEDAL

Science notes that the gold medal of the Royal Astronomical Society, London, has been awarded to Dr. Otto Struve, director of Yerkes and McDonald Observatories, in recognition of his work on observation and interpretation of the spectra of stars and nebulae. We understand that Dr. Struve will not make the trip to England to give the George Darwin lecture.

## "FLU FROM VENUS?"

Novel theories make their way into print, from time to time, which, treated with proper skepticism, are harmless and perhaps even thought-provoking. Sometimes, however, the unscientific layman may be led into accepting for fact what is at best merely a bold suggestion.

Thus, the science column of *Time* for February 21st carried an article under the above title, describing a theory by a medical professor at Upsala University, Stockholm. He is said to believe that bacteria might have been brought to the earth from Jupiter, Venus, or Mars. Contrary to what we heard in our elementary astronomy lectures, he believes that the planetary atmospheres containing methane and ammonia gases were more favorable to the origin of life than our own atmosphere. From them, *Time* quotes him as saying, "living organisms may have been transported to the earth by meteorites or by the propulsive power of the sun's rays." He does not explain how the "meteorites" could have gotten away from the planets. Moreover, on the assumption of propulsion, he seems to have overlooked the fact that Jupiter and Mars are farther from the sun than we are.

## ASTRONOMICAL NEWS LETTER FROM HOLLAND

The first of a series of astronomical news letters from Holland, dated November 12, 1943, has been received by the American Astronomical Society's Committee for the Distribution of Astronomical Literature. Nine technical papers published recently are abstracted, the major topics relating to variable stars and galactic structure.

J. H. Oort and A. J. J. van Woerkom, of Leyden, avail themselves of data by Shapley (Harvard) on the distribution of RR Lyrae-type variable stars in high latitudes, and Joy's (Mount Wilson) measures of velocities, to determine accelerations from which the mass of the galaxy can be estimated. Their result

of approximately  $10^{11}$  (100 billion) solar masses is in good agreement with previous estimates based on galactic-rotation data.

In a note on the structure of the inner parts of the galactic system, Prof. Oort finds: 1. that the "central mass" of the galaxy needed to account for the observed galactic rotational motions in the solar vicinity must extend out almost to the sun, except for about 10 per cent of this mass which seems to be concentrated very near the center; 2. the major part of the total number of globular clusters, even those outside the six-degree-wide "zone of avoidance" (region of obvious obscuration), are hidden from our view; 3. the rotational velocities of the galaxy in the vicinity of the sun must be somewhat less than 270 kilometers per second.

## COMET SCHAUMASSE

Comet Schaumasse (see Comet Predictions, these notes, March issue) has been located by H. L. Giclas at Lowell Observatory, Flagstaff, Ariz. He found it as a 15th-magnitude diffuse object on March 24th. Observations on three nights indicate that it was roughly seven degrees from the predicted positions. It is not expected to grow much brighter as its predicted closest approach to the earth was on March 27th and it had already passed perihelion in November.

## A NEW THEORY OF GRAVITATION

"It seems clear," says Prof. George D. Birkhoff, of Harvard's mathematics department, in his concluding remarks on "Newtonian and Other Forms of Gravitational Theory," appearing recently in the *Scientific Monthly*, "that the Newtonian theory will always stand as the realistic basis for astronomical calculations. Relativistic theories are likely to be used only in a few cases when large velocities enter and the minute relativistic effects can be observed."

In two articles, Dr. Birkhoff sketches the historical development of gravitational theories from before Newton through Einstein. Many of us are familiar with the astronomical observations that cast doubt upon the exactness of Newton's classical theory. Dr. Birkhoff points out briefly the successes and difficulties with Einstein's famous general theory. In astronomy, it explained the advance of the perihelion of Mercury, and predicted the bending of light from distant stars by the sun, and the red shift in lines of spectra of distant objects. On the other hand, in theoretic

cal physics, the theory encountered difficulties with electromagnetic forces. Further work by others led to alternative theories about which Dr. Birkhoff comments: "There is an undeniable air of unreality about them as well as in Einstein's generalized gravitational theory."

As long ago as 1928, he himself had introduced the concept of the relativistic "perfect fluid" in connection with the general theory. Not until 1942 did it occur to him to introduce the "perfect fluid" into the electromagnetic framework of Einstein's special theory of relativity. Then he developed a new theory which is found to account for second-order gravitational effects as well as does Einstein's theory, while incorporating electromagnetic as well as gravitational forces. The "perfect fluid" is one in which the velocity of a disturbance (when two portions of such fluids collide) is exactly equal to the velocity of light.

As to the amount of work involved, Prof. Birkhoff states, "The development of the theory and its application to the crucial phenomena is an elementary and simple matter requiring only four or five pages of routine mathematical work." Further investigation was desirable, however, and (according to Science Service) Prof. Birkhoff is now achieving further progress in collaboration with professors in Mexico. One problem of astronomical importance being attacked in the light of the new theory concerns the observed irregularities in the motion of the moon.

## A.A.S. MEETING

The preliminary notice announces the 72nd meeting of the American Astronomical Society for June 28-29, 1944, in Philadelphia. Sessions for papers and business sessions will be held at the American Philosophical Society, in Independence Square. A teachers' conference will be included in the program, and the tentative schedule also calls for a special demonstration at the Fels Planetarium, and for possible visits to nearby Flower, Cook, Sproul, and Haverford Observatories.

## AURORAE IN MARCH

Spring and fall are most favorable for auroral displays, as then sunspots pass more nearly central across the sun. March, with several brilliant aurorae, was no exception. In New England, in particular, nature spoiled a test blackout with a moving and colorful display on Sunday, March 26th. The phenomenon was predicted by many amateurs who several days earlier had noted a large sunspot approaching the central meridian of the sun. On March 18th, at Saco, Me., Francis D. Chapin observed unusually bright northern lights.



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# GLEANINGS FOR A.T.M.s

## IMPROVING THE REFLECTOR

(Concluded from last month)

4. "The light now converges to form the image and this image is magnified by the eyepiece. The ordinary 'astronomical' eyepiece of commerce is of the Huyghenian form, consisting of two simple, non-achromatic lenses. Possibly nine out of ten eyepieces in use by amateurs are of this type. They are admirable for use with refractors, but they are quite unsuitable for Newtonian reflectors, except those of unusually large focal ratio."

It has been the practice of amateurs in this country, we believe, to use positive eyepieces, which give much better performance than the negative eyepieces of which Mr. Hargreaves speaks. However, the average eyepiece obtainable by the amateur is not of high quality and none of them is really designed for use with reflectors. This editor has suggested often that someone should take the time to design an eyepiece for use with a reflecting telescope, properly corrected for this specific use. The reply has always been, "Why don't you do it?" Eventually, we suppose, it may come to that; at present, time and experience do not permit.

5. "Another matter requiring comment is the effect of changing temperature (almost always falling temperature) on the performance of the mirror."

This, as Mr. Hargreaves points out, applies to plate-glass mirrors. Most American amateurs use Pyrex mirrors exclusively, and the considerations of changes of figure with temperature probably do not apply to a significant degree.

6. "I now come to the supporting of the mirror and diagonal. It cannot be emphasized too much that telescope mirrors must not be subjected to any avoidable pressure; they bend very easily, and the distortion of the reflecting surface is not compensated by corresponding distortion of another surface, as in a lens. Mirrors are many times as sensitive as object-glasses in this respect."

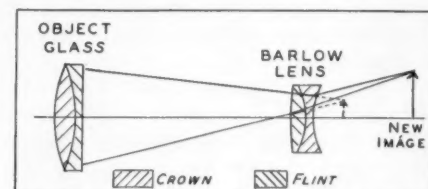
"The mirror itself is best supported at the back on three points, 120° apart, at distances from the center equal to two-thirds of the radius of the mirror. Nothing more elaborate than this is required for mirrors up to and including 12 inches aperture. . . . It will not do simply to lay a mirror (except a quite small one or a very thick one) on a more or less flat surface, because the back of the mirror will touch this surface at a few points only, and these points may be distributed very irregularly so that the mirror sags unequally."

"The mirror should be held against sideways movement by three abutments (or four if more convenient) equally spaced around the circumference, and the mirror must not be gripped between these abutments; there must be a very slight clearance, to avoid all risk of pressure."

7. "Something must now be said about the effect produced in the image by the obstruction of part of the light by the diagonal mirror. Of course it diminishes

the brightness of the image, but only by a very small amount. The central obstruction has the effect of diminishing the contrast in the images of planets (as does the secondary spectrum of an object-glass), and consequently makes fine detail less easy to see. It also makes close double stars less easy to resolve when the components are unequal in brightness.

"The smaller the central obstruction in relation to the aperture, the less these effects are. If its diameter is not more than one-sixth of the aperture the image is scarcely affected at all, and only one-thirty-sixth (less than 3 per cent) of the light is lost. Even if the diameter is as much as one-quarter of the aperture the effect is not serious—at least that is my opinion."



This schematic diagram shows the action of a Barlow lens with an ordinary refracting object glass.

Mr. Hargreaves brings up an interesting suggestion: to increase the equivalent focal length of a reflecting telescope by the use of a Barlow lens—a negative lens placed near the focal plane. The effect of this is to make an optical system on the same plan as the telephoto lens. By so increasing the equivalent focal length the errors of the eyepieces are made less noticeable through reduction of the field of view. Mr. Hargreaves says:

"Another remedy is to use a divergent lens (one that spreads the light instead of concentrating it) between the mirror and the focus, to make the rays from the mirror less convergent and therefore to increase the focal ratio—and, in effect, the focal length also. Such lenses are known as Barlow lenses, and they consist of two glasses cemented together, to correct the chromatic aberration of single

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lenses and also to correct the spherical aberration.

"Barlow lenses as usually supplied are about 1 inch in diameter and about 8 inches focal length. They are made primarily for use with refractors and are entirely suitable for that purpose. They are not, however, as a rule suitable for use with mirrors of focal ratios less than about 8, for much the same reason that eyepieces suitable for refractors are not necessarily suitable for reflectors.

"The matter is not quite so simple as in the case of eyepieces, because the performance of a Barlow lens depends on how far it is from the focus of the mirror. The further away it is, the larger is the diameter of the convergent beam that passes through it and the greater the aberrations. Moving it closer to the focus has the same effect as 'stopping down' a camera lens; only the middle of the lens is being used and the aberrations are smaller.

"The further the lens is from the focus, the greater the increase in the focal ratio of the system; the nearer it is to the focus, the smaller the increase.

"In order to increase the focal ratio of a mirror from 5 to 12, so that Huyghenian eyepieces can be used, the Barlow lens must be further from the focus of the mirror than it is when increasing the focal ratio from 8 to 12. The lens is therefore doubly handicapped.

"It follows that a Barlow lens can often be used successfully in a reflector to increase the focal ratio slightly, but it may fail when moved further from the focus to increase the focal ratio by a greater amount. If the focal ratio of the mirror is small, it is usually found that the image becomes unsatisfactory while the lens is still not far enough from the focus to increase the focal ratio to 12, which is the smallest value at which simple eyepieces can be used with complete success.

"The great need, therefore, is for an ample supply of Barlow lenses designed and made for use with mirrors of small focal ratio. Such lenses can be made—there is no doubt about it whatever, because they actually exist—under a different name. They are known as telenegative lenses, and were designed and made for photographers, not for astronomers. They were used in conjunction with existing camera lenses, very much as we use Barlow lenses, to obtain pictures on a large scale without the need for a correspondingly long and unwieldy camera. They have become obsolete, having been replaced by fixed-focus telephoto lenses, but although not so abundant as they were some years ago, they can still be obtained from dealers in second-hand photographic apparatus.

"Most of the leading optical firms—Goerz, Zeiss, Dallmeyer, Beck and others—designed and manufactured telenegative lenses. As they have not been made for many years there can be no harm in saying something about their relative merits. With the exception of those made by Zeiss, all that I have tried are useful in some degree, but some of them will not perform well under extreme conditions—

high amplifications or low focal ratios. By far the best that I have tried are those made by C. P. Goerz of Berlin. I use one of these on my telescope, the mirror of which has a focal ratio of 5.5, and it performs perfectly at an amplification of 8. Its focal length is only 60 mm., or about 2 3/8 inches. The effective focal length of the combination of mirror and lens is 630 inches, or rather more than 52 feet.

"I had several telenegative lenses of unknown makes, purchased many years ago, which are now in use by various observers with excellent results. I strongly advise anyone who is unable to obtain highly corrected eyepieces to try to obtain a telenegative lens, preferably one made by Goerz. Anyone buying a Dallmeyer telenegative is really obtaining two Barlow lenses, because as sold for photographic use it comprises two separate components, each of which is a cemented combination. I have actually found that one of these components will cure spherical over-correction in a mirror, while the other is a remedy for spherical under-correction!"

This is, of course, to be expected. A two-lens combination can only be made aberration-free if both components are achromatic and **neither** is spherically corrected. One, of course, must be under-corrected and the other overcorrected to balance.

If a Barlow lens is used in a reflecting telescope, the position of the eyepiece, of course, must be changed to correspond with the new focal plane, which will be somewhat farther away from the mirror than the old one.

Mr. Hargreaves summarizes:

"To sum up, a Newtonian reflector need not fear any comparison with a refractor of the same aperture, provided that

- (1) The tube is ventilated by an electric

## CORRECTION

Carl E. Roode, Westerly, R. I., has pointed out an error in this column in the February issue. In connection with the Huygens eyepiece, we stated that eyepieces with a ratio of 3 to 2 between the focal lengths of field and eye lenses are more frequently used for higher magnifications while those with a ratio of 4 to 1 are used for lower magnifications. Mr. Roode finds that this statement is the reverse of the correct one.

The reason is found in the position of the exit pupil. The greater the ratio between the focal lengths of field and eye lenses, the farther the exit pupil will be from the eye lens, and hence the greater the eye relief. In high-power eyepieces, it is important that the eye relief be large with respect to the focal length of the eyepiece, so a high ratio is desirable. Reference to the February article will show that the greater the aforementioned ratio, the farther the secondary focal plane will be beyond the eye lens. The objective lens is at a very great distance so the focal plane is, for practical purposes, the exit pupil.

We thank Mr. Roode for pointing out this error.

fan or is of skeleton construction—or both;

- (2) The diagonal is really flat;
- (3) Either well-corrected eyepieces are used, or, if Huyghenian eyepieces only are available, a well-corrected Barlow lens is employed to increase the effective focal length to twelve or more times the aperture;
- (4) The mirror is mounted so that air has free access to its back and edges (the lower end of the tube being open) and has been figured to suit these conditions of mounting;
- (5) The mirror and diagonal are supported so that they are free from strain;
- (6) The diameter of the obstruction caused by the diagonal is not much more than one-sixth of the aperture."

In regard to (4) above, Mr. Hargreaves pointed out in his address that it is helpful to figure a mirror especially for the conditions of mounting to be used, which means that the mirror should be mounted in its tube and tested upon an actual star. This probably will mean that if the mirror is taken into a testing room, it may be found to be imperfect under the conditions pertaining there, while perfect under actual conditions of use. This does not apply to as great a degree to Pyrex mirrors as it would to the plate-glass mirrors of which Mr. Hargreaves is speaking.

## THE EDITORS NOTE

(Continued from page 2)

ing it a "separate unit." He suggests—as a chapter heading: "How Hot Are the Stars?" but taboos: "What Is the Spectral Sequence?"

As perusal of Dr. Goedicke's outline will show, he does not intend to present the subject on a silver platter; there is plenty of mental exertion expected of the student. "I believe that a textbook should emphasize the means of arriving at solutions of problems in all cases, unless this takes the student hopelessly beyond his depth. The course is made more interesting as well as more valuable to the student if he participates in the battle for facts instead of only receiving the end product . . . formulae should be explained qualitatively . . . and then immediately applied. Furthermore, they should be applied in the most direct way possible, mathematical refinements being postponed until the student sees the principles clearly."

Dr. Goedicke mentions the problem of terminology; he notes that some texts give hundreds of references to astronomers by name whereas other texts mention almost none; and he suggests that work in allied fields, such as in geology concerning the age of the earth, ought to receive more attention. On many points such as these, he solicits the criticisms and suggestions of his contemporaries.

For persons everywhere, concerned with teaching or studying astronomy, we believe we may express the hope that in the near future Victor Goedicke may be the name of the author of a textbook on astronomy.

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# BOOKS AND THE SKY

## THE CONTRIBUTION OF HOLLAND TO THE SCIENCES

Edited by A. J. Barnouw and B. Landheer. Querido, New York, 1943. 373 pages. \$3.50.

IN THE preface to this book, P. Debye says, "Despite the fact that, in terms of travelling time, all nations are now situated like near neighbors living in a rather small community, it cannot yet be said that they know each other the way good neighbors should." The 20-odd chapters of this book, written by as many eminent Dutch or Dutch-American scholars, summarize the development of the various sciences as pursued in Holland, thereby bringing us closer to an appreciation of the national character of that country.

"The sciences" is a term used in its broadest meaning: over two thirds of the book is devoted to the humanities, social sciences, and arts; scarcely 80 pages, to the so-called "exact" sciences.

Practical, peace-loving, systematic—these are the characteristics of the nation as illustrated in many fields of endeavor.

"The brilliant growth of the exact sciences," writes B. Landheer in the section on political economy, "was created by the greater interest in the material aspects of life." A few of Holland's practical contributions are the first lenses, the microscope, the ophthalmoscope, and the "Leyden jar." That exact sciences

flourished is evidenced by the fact that Holland has had six Nobel prizewinners in physics and chemistry.

Throughout the pages of this book we meet again many old friends. Some of them are of such renown we had almost ceased to link their names to one country by emphasizing their association with a specific cultural or scientific field. Among the old friends are Erasmus, Grotius, Huygens, Kapteyn, Lorentz, Rembrandt, Spinoza.

The chapter on astronomy is written by Dr. Jan Schilt, director of Rutherford Observatory, Columbia University. Astronomy is also mentioned not only in the chapters on mathematics and physics, but also on Oriental studies, it having been an Oriental scholar, Golius, who was instrumental in the founding of the first state-owned observatory in Europe (at Leyden in 1633).

Astronomers usually assert that in their science national barriers do not exist. Much of the astronomers' international co-operation, of which we are so proud, can be traced to the Dutch astronomer, Kapteyn. Himself poorly equipped for observational work at Groningen, he succeeded in organizing programs for international co-operation on a major scale.

The authors have used tactful restraint in portraying the achievements of their illustrious predecessors. In general, the present generation has (for obvious reasons) not been discussed. By those

## SPHEROGRAPHICAL NAVIGATION

By DIRK BROUWER, FREDERIC W. KEATOR and DRURY A. McMILLEN

Foreword by CAPTAIN P. V. H. WEEMS, Annapolis

This book is a manual of instruction on a system of celestial navigation called Spherographical Navigation. While the system is based upon principles which are of considerable antiquity, it is new in the sense of its instrumentation and in its practical application to the solving of the problem of position. Reduced to its simplest terms, the Spherographical System embodies the use of a spherical plotting surface on which a fix of position is obtained by the direct plotting of the altitudes of selected celestial bodies. Practically no calculations are required, and no tables except the American Air Almanac or the Nautical Almanac. No solution of the spherical triangle is made for the computed altitude based upon either the dead reckoning or an assumed position.

Aside from the simplification of the solution provided by the method, and the speed with which a solution can be obtained, a distinct advantage lies in the great ease with which it can be learned.

The discoverer of this system is Drury A. McMillen, graduate of Sheffield Scientific School of Yale. The authors of the manual are Dirk Brouwer, Director of the Yale Observatory, and Frederic W. Keator, assistant professor of mechanical engineering and instructor of navigation at Yale.

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of us who hope to visit Holland for the first time, this book might be considered the Baedeker, not to the sights of Holland, but to its more important cultural and intellectual structure.

DORRIT HOFFLEIT  
Harvard College Observatory

### FOGS, CLOUDS AND AVIATION

W. J. Humphreys. Williams and Wilkins Company, Baltimore, 1943. 200 pages. \$3.00.

READERS of works on meteorology are presumably familiar with Dr. Humphrey's writings, including his *Fogs and Clouds* (1926). This last has been revised to conform in all particulars with the latest (1930) edition of the international *Cloud Atlas*, and with technical advances in aviation. After discussing evaporation and condensation (18 pages) and the different kinds of fog (20 pages), the author embarks on the main theme, "Cloud Forms" (115 pages), dealing with the 10 genera of clouds, the exact definition and the more important variations of each, in a simple, thorough manner, with a wealth of illustration which will be the delight of novice and veteran meteorologist alike.

There are 13 photographs of cirrus, three of cirrostratus, four of cirrocumulus, five of altocumulus, 11 of cumulus, and so on down the list—typical examples collected from all over the world, admirably reproduced. The use of different kinds of clouds in forecasting and as screens for the aviator is indicated; space, however, does not allow a detailed treatment of all the secondary types. There is a chapter on "Cloud Miscellany," concerned with cloud heights according to season and latitude; a final chapter on crepuscular rays, haloes, coronas; a short bibliography and an index. The whole is a most useful handbook for the observer, especially at this time when copies of the *Cloud Atlas* are showing signs of wear and tear, and new ones are unobtainable.

C. CHAPMAN

Blue Hill Meteorological Observatory

### THE "PARTICLES" OF MODERN PHYSICS

J. D. Stranathan. The Blakiston Company, Philadelphia, 1942. 571 pages. \$4.00.

THE RECENT discoveries of new elementary particles, the neutron, the positron, and the mesotron, are a characteristic feature of our contemporary physics. Therefore, it seems to be not a bad idea to build up a presentation of current atomic and nuclear physics around a description of all the elementary particles. The author starts with the "old particles," the electron and the proton, and also includes the photon, the basic element of radiant energy, in his family of "particles." In this way he has the opportunity to cover almost the whole ground of atomic and subatomic phenomena, including those of radiation. There is, probably, no other book in which the physical properties of all these particles are described in such a comprehensive and lucid way.

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By CAPTAIN W. J. VANDERKLOOT, Captain-Navigator, R.A.F. Transport Command. In press—ready in May.

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### Basic Air Navigation

By ELBERT F. BLACKBURN, Pan American Airways System. 300 pages, \$4.00.

Presents a simple yet comprehensive analysis of the problems confronting the air navigator from the time the flight is first planned until the destination is reached. The preflight, flight, and approach problems are presented and analyzed in the order encountered in practice. Celestial navigation is covered without abstract theory and star identification is taught without recourse to mechanical devices.

### Celestial Navigation

#### A Problem Manual

By WALTER HADEL, United Air Lines. 262 pages, \$3.25.

A problems-text in celestial navigation designed as a classroom instructional help that can be utilized as a textbook for the course in celestial navigation itself. The book contains 46 problems, 23 of which are solved in full, with unusually complete explanations of the navigation processes involved. A *Teacher's Manual*, containing complete detailed solutions to all unsolved problems in the manual, is available.

### Air Navigation Made Easy

By JAMES NAIDICH, Chairman, Department of Mathematics, Manhattan High School of Aviation Trades. In press—ready in May.

This simple, direct treatment of air navigation for the beginning student provides the training required by private civilian fliers. The text covers the basic principles of air piloting and dead reckoning, and shows how to read maps, how to fly by landmarks, how to measure direction, how to use the compass, how to correct for wind, how to plan a trip, and how to locate position in flight.

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the methods of measuring the size, the mass, and other properties of these tiny entities are presented, while the speculative approach is kept more in the background. The presentation is easily understandable for everyone who has some training in general college physics. There are only a few passages which need a little elementary calculus and elementary mechanics.

The ingenious way in which the author succeeds in presenting almost all of contemporary physics on the basis of a description of particles can be best seen by giving a glance to the table of contents: Gaseous ions and their behavior. The electron and the atomic character of electricity. The electrical discharge. Glow discharge in vacuum tubes. Cathode rays. Positive rays. Isotopes. Photons and the photoelectric effect. Radiation and absorption. X-rays. Natural radioactivity. Alpha, beta, and gamma rays. The positron. The neutron. Atomic nuclei. Artificial radioactivity. Cosmic rays. The mesotron. Particles? or waves? From this one gathers that the material covered in the book is of essential interest for everybody who wants to go a little deeper into astrophysics. An amateur astronomer who has, for instance, studied *Atoms, Stars and Nebulae*, will have no difficulty in understanding the present volume. It

is unavoidable that by the approach of this book some aspects of contemporary atomic and nuclear physics have had to be sidetracked. The exact status of such basic ideas as the equivalence of mass and energy, and the dualism between waves and particles, is described in a rather perfunctory way. To make these ideas really clear to the reader, one has to dive a little into Einstein's theory of relativity and Bohr's principle of complementarity, which could hardly have been done within the scheme of this book.

PHILIPP FRANK  
Harvard University

## NEW BOOKS RECEIVED

MR. TOMPKINS EXPLORES THE ATOM, G. Gamow, 1944, Macmillan. 97 pages. \$2.00.

The hero of *Mr. Tompkins in Wonderland* is back again, delving into the world of atomic physics in his own inimitable fashion.

WORLD WIDE PLANISPHERE, Wm. H. Barton, Jr., 1943, Addison-Wesley. Unpagged. \$2.50.

Four star charts of planisphere type, two for the northern and two for the southern hemisphere, with masks for different latitudes, make possible identification of constellations and the navigation stars at any season for any latitude.

BASIC PROBLEMS IN CELESTIAL NAVIGATION, Barton and Roth, 1944, Addison-Wesley. 56 pages. \$1.00. WORK KITS, 50 cents per set.

A graded series of problems divided into subjects, with examples worked in the text, and answers at the back of the book, for practice by students of navigation. Some tables are included. Work kits of 24 plotting sheets and 24 work forms are available for H.O. 208, H.O. 211, Ageton's A.P. Method, and H.O. 214.

LIFE ON MARS, Donald Lee Cyr, 1944, the author. 50 pages. \$1.00.

A treatise discussing the markings on Mars, and possible interpretation of them.

SPHEROGRAPHICAL NAVIGATION, Brouwer, Keator, and McMillen, 1944, Macmillan. 200 pages. \$5.00.

A system of navigation is described which embodies principles of plotting celestial altitudes on a sphere for determination of latitude and longitude. The only tables necessary for solution with this method are the *Air Almanac* or the *Nautical Almanac*.

INTRODUCTORY ASTRONOMY, J. B. Sidgwick, 1944, Philosophical Library. 137 pages. \$2.50.

A book for the beginning amateur observer, with chapters on the planets and the moon, and a number of star charts and descriptions of objects of interest.

## NOTICE

EFFECTIVE with both new and renewal subscriptions after April 1st, the price of *Sky and Telescope* is increased to \$2.50 per year for the United States and possessions, including service men and women overseas; to \$3.00 per year for Canada and countries in the Pan-American Postal Union; and to \$3.50 per year for all other foreign countries. The single copy sales price is increased to 25 cents. Bound sets of Volume II are \$5.50.

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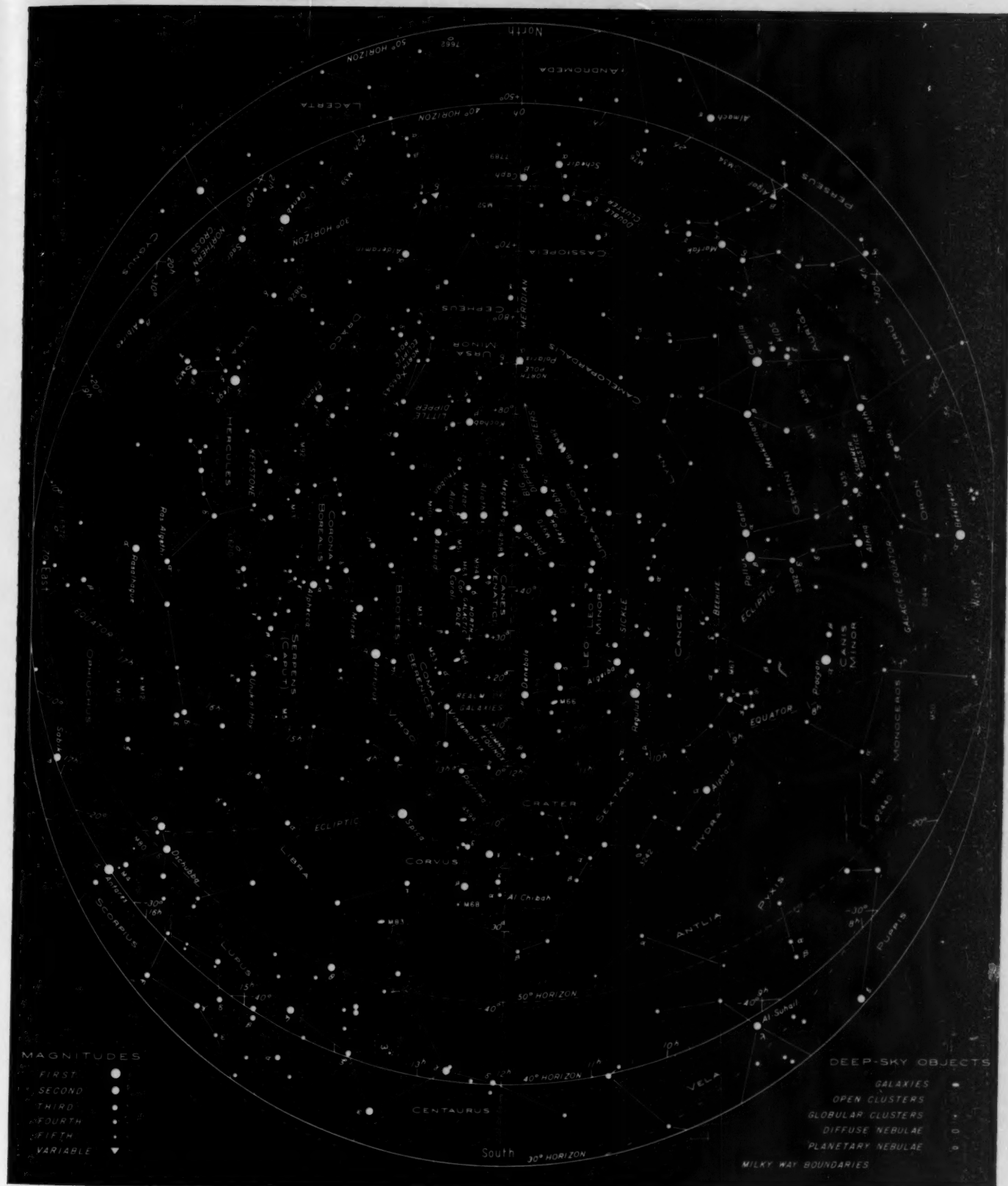
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## DEEP-SKY WONDERS

**A**MONG marvels for observation in the May skies are the objects listed here. The informal descriptions portray appearance in common telescopes, and numbers in parentheses are shown in Norton's *Star Atlas*.

**Hydra.** NGC 3242 (27'), 10h 22m, -18° 22'; bright, bluish-white planetary, 40" x 35". M68, 12h 36m.6, -26° 27'; small, bright globular.

**Coma Berenices.** M64, 12h 54m.3, +21°

47'; spiral, 8' x 4'; mag. 8. Large dim oval, with bright starlike center. Near bright star. M53, 13h 10m.2, +18° 24'; globular; diam. 3'.3. Star at edge.

**Canes Venatici.** M3, 13h 39m.7, +28° 39'; large globular.

**Hercules.** M92, 17h 15m.5, +43° 18'; globular, smaller than its popular neighbor, M13.

**Cancer.** M44 or Praesepe, 8h 34m.3, +20° 20', a famous open cluster. M67, 8h 45m.8, +12° 11'; an open cluster of 67 stars.

L. S. COPELAND

## STARS FOR MAY

as seen from latitudes 30° to 50° north, at 10 p.m. and 9 p.m. on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion. All co-ordinate lines are parts of circles.

# OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern war time.

## REMARKABLE TRANSITS OF JOVIAN SATELLITES I AND II

**T**HE OUTSTANDING event of 1944 for amateur observers, in my estimation, will be the spectacular emergence from transit of Jupiter's satellites I and II, Io and Europa, during the evening of May 4th, at an hour convenient for observers in the eastern half of the United States.

Moon II will begin to transit across the face of the planet's disk at 8:02 p.m., but daylight will prevent observation. Moon I will begin its transit at 8:41, and this ingress into the glare of the planet's disk may be seen if atmospheric conditions are perfect, but twilight will cause the satellite to appear as a very faint object in the telescope. At 10:56 p.m., II will emerge at Jupiter's west limb, and one minute later, I will make its reappearance, its greater orbital speed having almost overcome the original handicap of 39 minutes. The two egressions will appear simultaneous in our small telescopes, for reasons which I shall explain, and the overlapping of the two moons will cause them to resemble an elliptical figure elongated in the direction of Jupiter's polar axis.

The transits of the shadows cast by the moons on the disk of the primary will begin at 9:56 p.m. for I and at 10:38 for II. The planet's great distance from the earth, 485 million miles, will make observation of these shadows rather difficult in small telescopes, but they should be seen with a 3-inch refractor if the atmosphere is at all clear. On May 4th, because of the relative positions of the earth and Jupiter in their orbits, the angle between the earth and the sun as seen from Jupiter will be  $10^{\circ}8'$ , the greatest angular separation for 1944. This accounts for the intervals of 75 minutes and 156 minutes, respectively, between the instants of ingress of satellite and its shadow. When Jupiter was at opposition last February, the angular separation was  $0^{\circ}$ , and so there was no time interval, as explained in my article that month.

When, on May 4th, we observe I and II overlapping, the apparent distance, center to center, of the two moons in the direction of the planet's polar axis will be about  $1/3$  of their diameters, which are 2,300 and 2,000 miles, respectively.

The computed times for the egress of

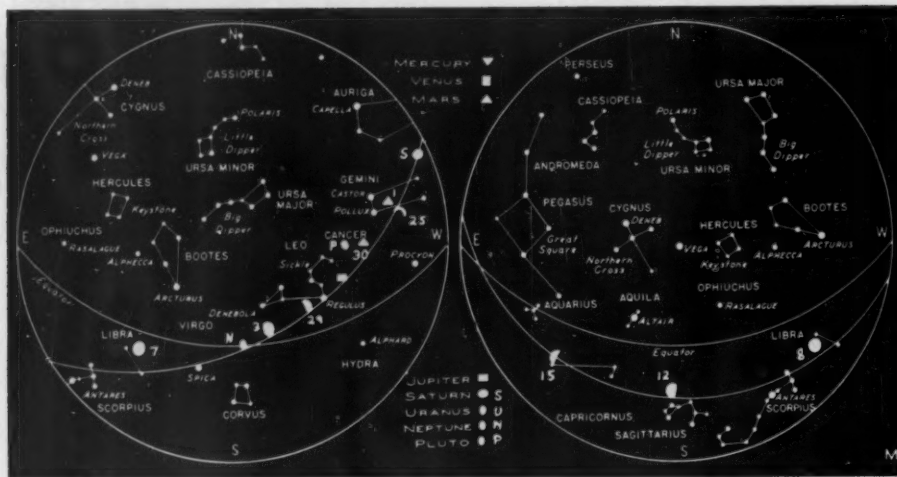
BY JESSE A. FITZPATRICK

the satellites, 10:56 p.m. for II and 10:57 p.m. for I, are for the instants their centers are in contact with the edge of the disk of Jupiter. II requires four minutes to move entirely clear of the limb and I,  $3\frac{1}{2}$  minutes. The latter, while having the greater diameter, is moving 8,000 miles per hour faster in the direction perpendicular to our line of sight. As mentioned in a previous article, it is at this time we can prove to our own satisfaction that these satellites appear in our small telescopes as disks and not just as points of light. The gradual increase in the size of the excrescence on the planet's edge during the four minutes makes this evident.

Perhaps the most interesting aspect of this configuration will occur after the satellites are entirely in the clear and are moving toward the west. The elongated disk, the southerly portion of which is I, will soon break up into two parts, and by the end of a half hour there will be a distinct separation as I rushes ahead and gradually leaves II in the rear. As moons III and IV are near their western elongations, the four satellites will then appear west of the planet.

Because of the coincidence that I revolves around Jupiter in very nearly 1.75 days,  $\frac{1}{4}$  of seven days, and II revolves in very nearly 3.5 days,  $\frac{1}{2}$  of seven days, similar configurations occur within a few hours of each 7-day period. On April 27th, the ingress of the shadows within one minute of each other happened at 8:00 p.m., but too early in the evening to be observed. On May 11th, the transit ingress of I at 10:36 p.m. will be followed four minutes later by the ingress of II. This phenomenon should be observed as early as 9:30 p.m. when I will appear farther east of the primary than II. Due to the former's greater orbital speed, it will catch up with and be in conjunction with II at 10:14 p.m. and pass it by a slight margin before the transit begins. This will afford another opportunity to observe the overlapping of the two satellites at the time of their apparent conjunction.

## THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 4:30 a.m. on the 7th of the month, and at 3:30 a.m. on the 23rd. At the left is the sky for 10:30 p.m. on the 7th and for 9:30 p.m. on the 23rd. The moon's position is given for certain dates by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

**Mercury** will be at greatest elongation west,  $24^{\circ}43'$ , on May 29th. Its path in the sky, however, will be  $9^{\circ}$  south of the sun's path on that date, which prevents this from being a favorable elongation for observers in the north temperate zone.

**Venus** is too near the sun to be of interest.

**Mars**, magnitude +1.7, is in Gemini and Cancer. On May 26th, it will have a geocentric separation north of the moon of  $1^{\circ}11'$ .

**Jupiter**, in Leo, is very conspicuous, and for telescopic observations, presents unusual satellite phenomena this month, described in the accompanying article.

**Saturn**, in Taurus, will be  $1^{\circ}2'$  north of Zeta Tauri on May 2nd.

**Uranus** is too near the sun to be of observational interest.

**Neptune** still retrogrades in Virgo, as described in the February issue.

**Pluto's** positions are given on the opposite page.

## OCCULTATIONS FOR TEXAS

Predictions are for longitude  $98^{\circ}0'0''$  W., and latitude  $30^{\circ}0'0''$  N. The data include: date, name of star, magnitude; G.C.T. in hours and minutes, a and b quantities in minutes, and position angle in degrees, at immersion; G.C.T., a and b quantities, and P.A., at emersion.

May 3, 308 B Leo, 5.9; 7:00.3,  $-0.7$ ,  $-1.9$ ,  $120^{\circ}$ ; 8:07.8,  $-0.3$ ,  $-1.6$ ,  $292^{\circ}$ .

May 4, b Vir, 5.2; 7:49.5,  $-0.1$ ,  $-3.4$ ,  $167^{\circ}$ ; 8:32.1,  $-0.8$ ,  $-0.2$ ,  $245^{\circ}$ .

May 6, 80 Vir, 5.8; 10:01.1,  $-0.6$ ,  $-1.7$ ,  $113^{\circ}$ ; 11:03.8,  $-0.1$ ,  $-1.4$ ,  $287^{\circ}$ .

May 10, 81 B Oph fol., 6.3; 8:05.1,  $-3.5$ ,  $+2.1$ ,  $52^{\circ}$ ; 9:04.3,  $-2.0$ ,  $-2.8$ ,  $333^{\circ}$ .

May 12, 30 Sgr, 6.2; 6:44.3,  $-0.3$ ,  $-1.4$ ,  $149^{\circ}$ ; 7:32.4,  $-2.6$ ,  $+2.6$ ,  $227^{\circ}$ .

May 15, Delta Cap, 3.0; ... ; 7:38.2,  $-0.3$ ,  $+0.8$ ,  $278^{\circ}$ .

May 30, Epsilon Leo, 5.3; 0:27.7,  $+0.1$ ,  $+5.7$ ,  $180^{\circ}$ ; 1:17.1,  $-4.7$ ,  $+2.4$ ,  $241^{\circ}$ .

The predictions, computed voluntarily



by Miss Tecla Combariati and J. Lynn Smith, of the U. S. Naval Observatory, are similar in form to those given in the **American Ephemeris** for 1944, pages 365-372.

Immersion at the dark limb (while the moon is waxing) are most desired. Reports should include the exact time of the phenomenon, and the observer's precise latitude, longitude, and elevation.

### JUPITER'S SATELLITES

On May 14th, the four moons will be east of the planet and in numerical order, with I nearest the primary.

For further details of the phenomena of Jupiter's satellites, see the special article in this department.

Jupiter's four bright moons have the positions shown below at 11:45 p.m., E.W.T., on the day preceding the date shown. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the **American Ephemeris**.

	West		East
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## OCCULTATIONS — MAY, 1944

Local station, lat. 40° 48'6 north, long. 4h 55m.8 west.

Date	Mag.	Name	Immersion	P.*	Emersion	P.*
May 1	7.1	BD +13° 2237	8:36.8 p.m.	144°		
3	5.9	308 B Leonis	2:56.5 a.m.	78°	3:45.8 a.m.	327°
4	5.2	b Virginis	3:28.7 a.m.	122°	4:26.2 a.m.	283°
12	6.2	30 Sagittarii	3:14.3 a.m.	96°	4:37.9 a.m.	267°
29	5.3	1 Leonis	8:38.2 p.m.	102°	9:57.9 p.m.	315°
30	7.0	BD +6° 2470	10:18.7 p.m.	154°		

\*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

### PLUTO'S POSITIONS

MANY readers have requested an ephemeris of positions of Pluto, although the planet can only be seen with large telescopes. These positions, supplied by Mount Wilson Observatory, appeared originally in the February, 1944, number of the **Publications** of the Astronomical Society of the Pacific:

1944	U. T. Oh	R. A. (1944.0)	Dec.
		h. m. s.	°
April 10		8 41 18	+24 2.1
20		8 41 14	24 1.6
30		8 41 20	24 0.4
May 10		8 41 37	23 58.5
20		8 42 5	23 56.0
30		8 42 43	23 53.1
June 9		8 43 30	23 49.6
19		8 44 25	23 45.9
29		8 45 27	23 41.8

### COMET ENCKE

AMATEURS with large telescopes may wish to search for this comet, making its 42nd return to the sun since 1786. It will pass perihelion, about 1/3 of an astronomical unit from the sun, on August 7th, after which it will be unfavorably located for observers in the Northern Hemisphere. As it will be near conjunction at the time of perihelion, its

distance from the earth will remain more than one astronomical unit, and its brightness will be well below naked-eye visibility. The following positions are taken from the **Handbook** of the British Astronomical Association:

1944	U. T. Oh	R. A. (1944.0)	Dec.
		h. m.	°
May 2		1 34.0	+15 56
6		1 42.5	16 48
10		1 51.4	17 41
14		2 00.7	18 35
18		2 10.5	19 30
22		2 20.8	20 26
26		2 31.7	21 22
30		2 43.2	22 18
June 3		2 55.5	+23 15
7		3 08.7	24 11
11		3 22.8	25 06
15		3 38.0	25 59
19		3 54.4	26 50
23		4 12.2	27 36
27		4 31.6	28 16
July 1		4 52.6	+28 47
5		5 15.4	29 07
9		5 40.1	29 11

### PHASES OF THE MOON

Full moon	May 8, 3:28 a.m.
Last quarter	May 15, 7:12 a.m.
New moon	May 22, 2:12 a.m.
First quarter	May 29, 8:06 p.m.

## PLANETARIUM NOTES

*Sky and Telescope* is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

### ★ THE BUHL PLANETARIUM presents, in May, WONDERS OF THE UNIVERSE.

In this production, visitors take a grand tour of the universe to see its almost countless wonders, and to obtain a comprehensive view of its structure. The drama of eclipses is enacted as the eclipsed moon turns red, as the eclipsed sun permits the solar corona to flash forth. Comets glow weirdly for us, meteors streak across the heavens, the planets perform their endless celestial dance, the sky throbs with the radiance of northern lights. The magic of the telescope then takes us far beyond the worlds of our solar system to inspect the innumerable stars of the Milky Way galaxy, the star clusters, the nebulae, and finally the farthest objects known — the other galaxies of cosmic space.

### ★ THE HAYDEN PLANETARIUM presents, in May, COMETS AND METEORS. (See page 12.)

In June, THE SUN AND ECLIPSES. Our sun supports life on the earth. How is its energy sent to us? Where does its energy come from? Will it give out soon? What is it made of and how do we know? These and many other questions will be answered and demonstrated. Again we bring the sun's big image inside the planetarium dome on clear days.

#### ★ SCHEDULE BUHL PLANETARIUM

Mondays through Saturdays (except Tuesdays) ..... 3 and 8:30 p.m.  
Sundays and Holidays ..... 3, 4, and 8:30 p.m.  
(Building closed Tuesdays)

★ STAFF—Director, Arthur L. Draper; Lecturer, Nicholas E. Wagman; Manager, Frank S. McGary; Public Relations, John F. Landis; Chief Instructor of Navigation, Fitz-Hugh Marshall, Jr.; Instructor, School of Navigation, Edwin Ebbighausen.

#### ★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays ..... 2, 3:30, and 8:30 p.m.  
Saturdays ..... 11 a.m., 2, 3, 4, 5, and 8:30 p.m.  
Sundays and Holidays ..... 2, 3, 4, 5, and 8:30 p.m.

★ STAFF—Honorary Curator, Clyde Fisher; Curator, William H. Barton, Jr.; Associate Curator, Marian Lockwood; Assistant Curator, Robert R. Coles (on leave in Army Air Corps); Scientific Assistant, Fred Raiser; Lecturers, Charles O. Roth, Jr., Shirley I. Gale, John Saunders.